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BIOCHEMISTRY.—*The bacteriostatic and the bactericidal action of certain organic sulphur compounds.*[1] EDWARD L. EVERITT and M. X. SULLIVAN, Georgetown University.

For a number of years in the field of chemotherapy investigations have been carried on relative to the treatment of various infections of man by certain chemicals. The importance of the use of chemical substances lies in the possibility of checking or destroying the invading organisms, or in offsetting the products of the activity of the organisms in question. Since many compounds having fungicidal or bactericidal properties are harmful to the body tissues, very few chemical compounds have been found useful for internal application, such as injection into muscles or directly into the blood stream.

Within the past few years, however, several compounds have been discovered that are of value in the treatment of pneumonia and of certain streptococcic infections. Thus, Rosenthal (1934) investigated the action of sodium formaldehyde sulphoxylate on virulent pneumococci and found it effective against one strain of the organism among the 32 strains studied with mice. The sulphoxylate, as the complex is called, was injected into mice inoculated with the particular strain of pneumococci under investigation. In contrast to its effectiveness in mice was the fact that in vitro tests showed that the compound had little if any bactericidal or bacteriostatic action. Domagk (1935) in Germany then announced a discovery that has revived chemotherapeutic research. He found that the addition of a sulphamide group into certain azo dyes would protect or cure mice infected with fatal doses of hemolytic streptococci and that this effect was not correlated with in vitro experiments, in which the compounds had little effect on the organisms.

The compounds found most effective by Domagk were: 4-sulphonamide-2, 4-diamino-azobenzene, and 4-sulphonamide-phenyl-2-azo-7-acetylamino-1-hydroxynaphthalene-3, 6-sodium disulphonate, which

[1] The data in this paper are taken in part from the dissertation presented by Edward L. Everitt in partial fulfillment of the requirements for the degree of doctor of philosophy, Georgetown University, 1937. Received July 9, 1940.

were named respectively prontosil and prontosil soluble. Domagk's work was soon followed by that of Trefouel, Nitti, and Bovet (1935), who described a sulphonamide product that did not contain the azo-group but that still had chemotherapeutic activity. This compound, p-aminobenzene sulphonamide, $H_2N\langle\bigcirc\rangle SO_2NH_2$, was first known as prontylin and has been extensively used in this country and abroad under the name sulphanilamide. It has been found very valuable therapeutically against several infectious diseases, streptococci infections in particular. An excellent review with 162 references has been made by Holman and Duff (1938).

In work with various sulphur compounds, started long before the publication of Domagk's work and subsequent work of others on sulphanilamide and its main derivatives, we found that a number of organic sulphur compounds investigated in vitro had a fungistatic or a fungicidal action on various molds (Everitt and Sullivan, 1940). The compounds made use of in the mold studies were then tested as to their bacteriostatic and bactericidal actions, with especial attention to the streptococci and staphylococci.

The culture media employed in the study of the growth of the bacteria were those commonly used in bacteriological work and were made up as follows, (A) and (B):

(A) BROTH MEDIUM

Neopeptone	10 grams
Sodium chloride	5 grams
Water to make	1,000 cc

This culture medium was adjusted to pH 7.6, and 50-cc portions were placed in 125-cc Erlenmeyer flasks. The sulphur compounds were added in specified amounts, and the flasks were plugged with cotton and sterilized at 15 pounds pressure for 30 minutes. Certain flasks without the particular compounds served as controls.

(B) BLOOD AGAR SLANTS

The viability of the microorganisms on medium (A) with and without the added sulphur compounds was further determined by making transfers to blood agar slants. These slants were made by adding 0.5 cc of sterile blood to tubes of agar made up as follows:

Beef extract	3 grams
Peptone	10 grams
Sodium chloride	5 grams
Agar-agar	15–18 grams
Water to make	1,000 cc

The agar solution was then tubed, plugged with cotton, and sterilized at 15 pounds pressure for 30 minutes. The sterile blood was added by means of sterile pipettes to these sterilized tubes of agar after they had been cooled in a slanting position.

In the study, the bacterial culture medium (broth medium) was inoculated by the addition to the various flasks of two drops of an 18- to 24-hour peptone medium growth of the particular organism.

The inoculation of the blood agar slants was made by transferring a 6-mm loopful of the culture media to the surface of the slants.

In each case, whether in broth or agar slants, the bacterial cultures were incubated at 37° C.

A series of preliminary tests with a number of sulphur compounds to determine their bacteriostatic and bactericidal properties was undertaken with the use of *Staphylococcus aureus* as the test organism. As this organism was found very resistant, its study was deferred until other possibly more potent compounds could be made, and attention was paid to the streptococci, considered of more importance from the standpoint of human infections. The streptococci employed were (a) *Streptococcus hemolyticus* (oyler strain) isolated from a patient with an infection on the dorsal surface of the hand and found capable of producing beta hemolysis; (b) *Streptococcus hemolyticus epidemicus* Group A, obtained from Dr. Alice Evans, National Institute of Health. It belonged to Lancefield's group A and was virulent to white mice; (c) *Streptococcus viridans* No. 2, obtained from Dr. Cecil in 1935. It produced alpha hemolysis. All the streptococci used were provided by the Department of Bacteriology, Georgetown University Medical School.

In preliminary work about 50 chemicals previously tested in mold growth and listed in the reference to the fungicidal and fungistatic action of various sulphur compounds by Everitt and Sullivan (1940) were tested for their effect on the streptococci. Only a few seemed promising from a bacteriostatic or bactericidal standpoint. These possibly useful compounds are as follows:

(3) Phenothioxine
(10) Phenyl thioarsenite
(11) 4-chloro-2-nitrophenyl sulphur amine
(14) Thioacetamide
(15) Mercaptobenzothiazole
(16) Phenylbenzothiazole
(17) Sodium diethyldithiocarbamate
(18) Diethylthiourea

(31) Thiobarbituric acid
(32) Benzyl disulphide
(33) Colloidal sulphur (sulphur diasporal)
(34) Colloidal sulphur (sulisocol)
(36) 1,2 naphthoquinone-4-sodium sulphonate

The effect of the various compounds was determined by incubating the broth culture containing the test material for 24 to 96 hours and at each twenty-fourth hour transferring a loopful to blood agar slants for a further judgment as to growth. The effect of the compounds on the bacteria is given in Tables 1, 2, and 3.

TABLE 1.—STUDY OF THE MOST PROMISING SULPHUR COMPOUNDS FOR ACTION ON STREPTOCOCCUS HEMOLYTICUS (OYLER STRAIN)

Sulphur compound No.	Amount used in 100 cc	Time interval of incubation in hours on medium (A) before transplanting to blood agar[1]			
		24	48	72	96
	mg				
Control...	—	+	+	+	
(3)....	20	+	0	0	0
	15	+	+	1 colony	0
(14)....	15	15 colonies	+	+	0
(15)....	10	0	0	0	0
(16)....	10	0	+	+	+
(17)....	15	0	0	0	0
(18)....	15	+	0	0	0
(31)....	15	1 colony	+	0	0
(32)....	20	0	0	0	0
(33)....	20	0	0	+	+
(34)....	20	+	0	0	0
(36)....	15	0	0	0	0

[1] The sign (+) signifies growth on the blood agar, (0) no growth.

TABLE 2.—STUDY OF SULPHUR COMPOUNDS ON GROWTH OF STREPTOCOCCUS HEMOLYTICUS EPIDEMICUS

Sulphur compound No.	Amount used in 100 cc	Time interval of incubation in hours on medium (A) before transfer to blood agar[1]				
		24	48	72	96	120
	mg					
Control...	—	+	+	+	+	0
(3)....	10	0	0	0	0	0
(10)....	10	0	0	0	0	0
(11)....	15	1 colony	0	0	0	0
(14)....	10	0	0	0	0	0
(15)....	10	0	0	0	0	0
(16)....	10	+	0	+	0	0
(18)....	15	6 colonies	0	0	0	0
(31)....	15	+	+	+	+	
(32)....	15	+	+	+	+	
(33)....	20	0	0	0	0	
(34)....	20	0	0	0	0	
(36)....	10	+	0	0	0	0
	5	+	0	0	0	0

[1] The sign (+) signifies growth on the blood agar, (0) no growth.

TABLE 3.—ACTION OF CERTAIN OF THE SULPHUR COMPOUNDS ON STREPTOCOCCUS VIRIDANS INCUBATED IN 24-HOUR PERIODS ON MEDIUM (A) AND A LOOPFUL OF BROTH TRANSFERRED TO BLOOD AGAR SLANTS TO DETERMINE GROWTH

Sulphur compound No.	Amount used in 50 cc	Time in hours				
		24	48	72	96	120
	mg					
(3)....	5.0	+	+	+	+	+
	7.5	+	+	0	0	0
(15)....	5.0	15 colonies	+	+	+	0
(16)....	5.0	+	+	+	+	+
(17)....	7.5	+	+	+	+	3 colonies
(18)....	7.5	+	+	+	+	+
(10)....	5.0	1 colony	+	2 colonies	+	0
(11)....	7.5	+	+	+	+	+

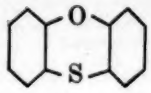
A study of Table 1 will show that a number of compounds have a retarding action in vitro on the growth of *Streptococcus hemolyticus* (oyler strain). These compounds are 3, 15, 17, 18, 32, 33, 34, and 36, and of these 15, 17, and 36 were the most effective. Similarly, as shown in Table 2, a number of compounds inhibited the growth of *Streptococcus hemolyticus epidemicus*. These compounds are 3, 10, 11, 14, 15, 16, 18, 33, 34, and 36.

Of the compounds tested and found inhibiting on both strains of streptococci there may be listed nos. 3, 15, 18, 33, 34, and 36. Compounds 33 and 34, colloidal sulphur preparations, may be effective because they are alkaline in reaction and may change the hydrogen-ion concentration of the culture medium sufficiently to inhibit the growth of the organisms. Since this question called for a detailed study, these compounds were set aside for further consideration. Since compound 36 (1, 2 naphthoquinone-4-sodium sulphonate) was early shown by Herter (1905) to have more or less toxicity toward animals, the use in offsetting the action of streptococci in vivo might be questionable.

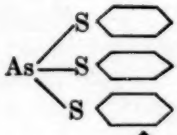
Finding that various compounds checked the growth of *Streptococcus hemolyticus* and *Streptococcus hemolyticus epidemicus*, we decided to study their effect on the highly virulent microorganism *Streptococcus viridans*, the checking of which has long been a desired need in medical practice. The results with *Streptococcus viridans* are shown in Table 3.

It is obvious from Table 3 that *Streptococcus viridans* is more resistant to the action of the various compounds than are *Streptococcus hemolyticus* and *Streptococcus hemolyticus epidemicus*. *Streptococcus viridans* infection in human beings usually has a very unfavorable outcome and is one of the organisms for which some effective com-

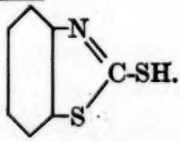
pound should be found. Of the compounds tested, only three seem to have some inhibiting action on *Streptococcus viridans*. These compounds are nos. 3, phenothioxine,



10, phenyl thioarsenite,



and 15, mercaptobenzothiazole,



Of these compounds, mercaptobenzothiazole was on hand in plentiful supply, and some attention was paid to it from a chemical and a clinical viewpoint. As may be seen from its formula, it is an organic sulphur compound containing nitrogen and in addition a -SH group. This compound, which was first made by Hofmann (1887), has been used for a number of years in the rubber industry as an accelerator of vulcanization. Its use for this purpose seems to have been first suggested by Bedford and Sebrell (1921). It may be purchased from the Eastman Kodak Co. It is moderately soluble in alcohol, ether, chloroform, and benzol, alkalies, and alkali carbonate solutions but not very soluble in water.

Roark and Busbey (1935) state that mercaptobenzothiazole in concentrations of 0.01 to 0.10 percent was effective in controlling a fungus living on wood and that it has been used in controlling aphids and mosquito larvae. Davis (1930) reported on the toxicity of the compound. He injected an aqueous solution of it into guinea pigs and a total injection of 14.5 mg in 20 days did not produce any injurious effects on the animals. Also, medical examinations of the men working with mercaptobenzothiazole over a period of years in the Goodyear Tire & Rubber Co. did not show any toxic condition or dermatoses. We have given 20–100 mg of the compound by mouth to guinea pigs weighing 400 grams with no gross evidence of toxicity. The disadvantages of using mercaptobenzothiazole are its slight solubility and its tendency to chemical change when in an alkaline solution.

In preliminary work, phenothioxine in a slightly alkaline medium and at a level of 20 mg per 100 cc has shown good bacteriostatic action on the streptococci, even on *Streptococcus viridans*. Phenothioxine

however, is rather difficultly soluble in the culture media, but it can be converted readily to a more soluble sulphonate which will be investigated further in vitro and in vivo.

SUMMARY

In testing about 50 organic sulphur compounds as regards their effect on the growth of various streptococci, a number of compounds were found to have more or less bacteriostatic or bactericidal power at a level of 100 parts per million of peptone broth. The most promising compounds are phenothioxine, which showed marked bacteriostatic action on *Streptococcus hemolyticus* (oyler strain) and *Streptococcus hemolyticus epidemicus* and considerable inhibition of *Streptococcus viridans;* and mercaptobenzothiazole, which showed bactericidal action on *Streptococcus hemolyticus* (oyler strain) and on *Streptococcus hemolyticus epidemicus*, but not on *Streptococcus viridans*. The criterion of biological action of the various compounds was the degree of growth on blood agar slants after a period in peptone broth culture with and without the compound under study.

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PALEOBOTANY.—*A* Cusparia *from the Pliocene of trans-Andean Bolivia.*[1] EDWARD W. BERRY, Johns Hopkins University.

The specimens on which the following note is based were collected many years ago by Dr. Edwin Kirk, to whom I am indebted for them as well as the information regarding their geological setting.

They were collected at Agua Salada (lat. 21° 50′ 20″ S., long. 63° 30′ W.), which is about 25 kilometers northeast of Yacuiba, Bolivia, from the surface of an argillaceous deposit, some thousands of feet above the base of what Bonarelli[2] called the "Terciario subandino." This is more or less the equivalent of what Madgwick called the Upper Sacarigua beds; Heald and Mather the San Ysidro formation; and Mather the Tatarenda formation. Similar deposits in this general region were earlier christened the Jujuy formation by Steinmann. Beds of this character extend in the sub-Andean zone through many degrees of latitude and appear to be lithologically and genetically similar. They appear to be poorly fossiliferous everywhere, although doubtless detailed searching of outcrops in this superficially explored region might greatly modify this statement. Bonarelli and others have reported obscure molluscan remains and ostracods; Harrington collected insects, which were described by Cockerell(1925); Kraglievic records a sloth cranium (*Scelidodon*); and Kirk collected a mammalian jaw which Gidley regarded as of Pliocene age. Fossil leaves of *Cassia chrysocarpoides* Engelhardt were collected at Carandaiti,[3] which is about 150 miles north of Agua Salada.

This last is a common Potosi form and a *Corbicula* mentioned by Bonarelli also occurs in the inter-Andean Pliocene.

In previous discussions of the date of the final uplift of the Andes mention has been made of the thick series of erosion products that accompanied this uplift, remnants of which skirt the mountains from eastern Colombia southward to western Argentina and from which a considerable number of fossil plants have been described, as at the Rio Aguaytia locality in eastern Peru, or molluscan faunas as near Pebas, Peru. Some of the latter as well as many of the plants are identical with inter-Andean forms from the Cuenca and Loja basins in Ecuador, from the headwaters of the Orinoco system in Colombia, or the headwaters of the Amazon system in eastern Ecuador and Peru, the Territory of Acre in western Brazil, and in eastern Bolivia.

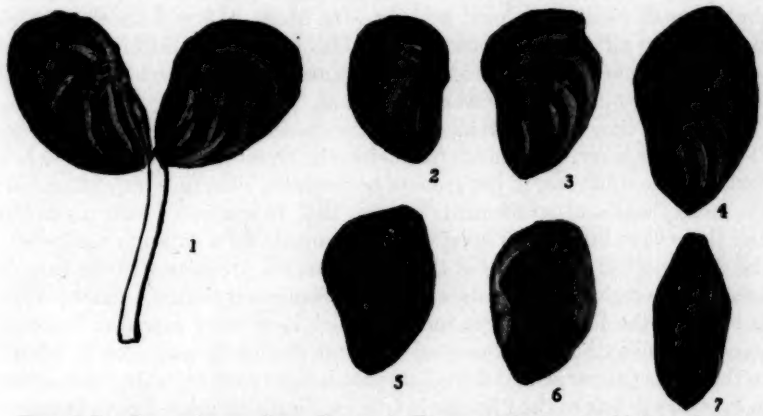
It appears to me that they all clearly represent a part of the same

[1] Received July 25, 1940.
[2] BONARELLI, G. Anal. Min. Agr. 15: (1). 1921.
[3] BERRY, E. W. Johns Hopkins Univ. Stud. Geol. No. 13: 51. 1939.

geological epsiode and are of about the same age, although it obviously would be inaccurate to assume exact correlation of named lithologic units through this vast distance, especially with the realization of the difficulty of the country and the reconnaissance nature of its exploration. The fossil fruits from Agua Salada are tentatively identified as belonging to the rutaceous genus *Cusparia* and may be described as follows:

Cusparia yacuibana Berry, n. sp. Figs. 1–7

Carpels unsymmetrically egg-shaped ranging from irregularly obovate to subrhomboidal in lateral profile, somewhat compressed, rounded above and



Figs. 1–7.—*Cusparia yacuibana* Berry: 1, Two specimens assembled to depict a fruit consisting of two capsules; 2–4, lateral views of valves; 5, 6, internal views of valves showing outline of the single seed, placenta, and dorsal dehiscence canal; 7, ventral view of partly opened capsule. All ×2.

obtusely pointed proximad, a slight sinus on the ventral border. Substance crustaceous or bony. Surface with a characteristic sculpture, heavily rugose. Ribs comprising a broad, rounded, lunate rib originating near the middle of the ventral margin curving outward and downward subparallel with the dorsal margin. This central rib divides the surface into two regions—above it there are at least two major and one or two minor ribs, all subparallel; below it there are three or four similar ribs more parallel with the axis of the fruit and gradually becoming obsolete at its base. All the ribs are subject to considerable variation in both extent and magnitude. Dimensions: Length, ranging from 7 to 10; maximum width, 5 to 7; thickness, 4 to 5 mm.

Carpel is tardily dehiscent into two equal valves, well shown in Figs. 1–4. At least one specimen preserves the single reniform seed, which is hard and smooth and exactly fills the cavity. By voluntary shifting the focus of the eyes the observer of Figs. 5 and 6 can get the exact picture of the valve with the seed preserved except that the seed is smooth and rounded dorsally and does not extend into the canal through the upper dorsal wall of the capsule. This canal has been puzzling. It can not be detected in all the specimens, nor is any trace of it shown from the outside in the unopened speci-

mens. It is present in the majority of dehisced valves and appears to make the dorsal limit of dehiscence. The wall must have differed naturally in structure along this line although nothing can be made out microscopically. In Fig. 3 a considerable sinus on the upper dorsal margin is shown at this point.

The seed is interpreted as pointed at the base, although no trace of a stylar canal is preserved in the capsule wall. The hilum is supposed to be at the concavity on the ventral side, and the swollen wall around which it fits is supposed to represent the placenta. No trace of a funicular canal can be detected in any of the specimens.

These carpels, seemingly so individualistic and well marked, have baffled both identification and interpretation for many years. I have submitted them to systematists at some of our larger herbaria as well as to experts in the study of fossil carpology, such as Mrs. Reed, the well-known British authority, to all of whom I am grateful. One insuperable difficulty as usual is to find comparable recent material since most botanical species are founded on herbarium material of flowers and leaves.

For a long time I was convinced that the specimens represented the stones of a drupe or berry. Arguments for such an interpretation are the traces of a dark organic substance in the grooves between the ribs; the stony character; the lack of traces of attachment; the fact that 10 specimens were unopened and there were but 28 half specimens. Arguments for a capsular nature was the dehiscence of a majority of the specimens; the prevalence of the capsule habit in this region of the Rutaceae and the somewhat similar ornamentation in many of the Recent genera some of which have bony capsules. The consensus of the authorities consulted was that the fossils were closely related to the genus *Cusparia*, and since I can not believe that an extinct genus was in existence as late as the Pliocene in tropical South America, I have ventured to describe them as an extinct species of that genus, and I am optimistic enough to expect that when the botanical exploration of that vast region shall be more complete than it now is this extinct species may be found to be a still existing one. Decision as to habit and orientation has also been difficult. At first I assumed that the more pointed end to which the ribs converged was the apex, but a review of the literature and such recent material as was available convinces me that the widest part of the capsule is distad and the narrower end from which the ribs diverge is the proximal part. All the material that I have seen has the ornamentation disposed in this pattern.

There are many similar, but not identical, Recent forms in the Cuspariеae especially in the genera *Cusparia*, *Pilocarpus*, and *Raputia*. In *Cusparia*, to which the fossils conform more closely than to the others, the mature capsules are one to three and rarely four in number. I am giving a restoration of the fossil in which two capsules are shown as having matured.

The subfamily Cuspariеae comprises 16 genera with upward of 100 known species, all American, in the existing flora. Engler, who prepared the account of the Rutaceae in Martius's *Flora Brasiliensis* and for *Das natürlichen Pflanzenfamilien*, discussed the geographical distribution in a special pa-

per[4] in 1816, since when there has been considerable botanical exploration, and it now seems probable that most of the genera of the Cusparieae, certainly all the larger genera, may be expected to be found anywhere in the neotropical region of South America centering in the Orinoco and Amazon basins, extending to the Greater Antilles (Cuba, Haiti, and Puerto Rico) in the genus *Ravenia*, to Central America and southern Mexico in the genus *Erythrochiton*, to Paraguay and Uruguay in the genus *Pilocarpus*, and to the eastern Andean slopes of Peru and Bolivia in the genera *Erythrochiton* and *Cusparia*, and probably in the majority of other genera of this subfamily.

At least two species of *Cusparia* (*ramiflora* and *toxicaria*) are recorded from the upper Amazonian drainage basin, and one (*pilocarpoidea*), although with capsules not close to the fossil, is found in eastern Bolivia.

Cusparia, so far as I know, has not previously been found fossil, and the same statement is true of 12 of the other genera comprising this subfamily. The three genera, in addition to the present occurrence of *Cusparia*, which have furnished fossils are (1) *Pilocarpus*, species of which are recorded from the lower Miocene of Coronel, Chile, the Pliocene of Psillypampa, Bolivia, and the Pliocene of Aramary and Marahii in eastern Brazil; (2) *Ticorea*, which is recorded from the lower Miocene of Chile; and (3) *Erythrochiton* with a species associated with *Ticorea* and a second from the Pliocene of eastern Brazil (Aramary in the State of Bahia and Fonseca in the State of Minas Geraes).

BOTANY.—*New species and new names among Arizona Asteraceae.*[1]

S. F. BLAKE, U. S. Bureau of Plant Industry.

The following new species, new varieties, and new combinations are published here in order that they may be available for the *Flowering plants and ferns of Arizona*, by T. H. Kearney and R. H. Peebles, now in course of publication by the U. S. Department of Agriculture.

Kuhnia rosmarinifolia Vent. var. **chlorolepis** (Woot. and Standl.) Blake

Kuhnia chlorolepis Woot. and Standl. Contr. U. S. Nat. Herb. **16**: 177. 1913.

Aplopappus croceus Gray var. **genuflexus** (Greene) Blake

Pyrrocoma genuflexa Greene, Pittonia **3**: 348. 1898.
Haplopappus croceus subsp. *genuflexus* Hall, Genus Haplopappus 99. 1928.

Chrysothamnus pulchellus (Gray) Greene var. **baileyi** (Woot. and Standl.) Blake

Chrysothamnus baileyi Woot. and Standl. Contr. U. S. Nat. Herb. **16**: 181. 1923.
Chrysothamnus pulchellus subsp. *baileyi* Hall and Clements, Phylogen. Meth. Taxon. 194. 1923.

[4] ENGLER, A. *Über die geographische Verbreitung der Rutaceae im Verhältnis zu ihrer systematischen Gliederung.* Abs. Preuss. Akad. Wiss. 1896: 1–27, pls. 1–3. 1896.

[1] Received October 8, 1940.

Chrysothamnus viscidiflorus (Hook.) Nutt. var. **elegans** (Greene) Blake

Chrysothamnus elegans Greene, Erythea 3: 94. 1895.
Chrysothamnus viscidiflorus subsp. *elegans* Hall and Clements, Phylogen. Meth. Taxon. 183. 1923.

Chrysothamnus viscidiflorus var. **molestus** Blake, var. nov.

Suffrutex 8–12 cm altus pluricaulis; caules albo-corticati foliosi normaliter infra inflorescentiam simplices ut folia subdense hirtelli pilis brevibus patentibus albis conicis saepe glanduloso-capitatis; folia linearia vel infima anguste lineari-spathulata calloso-apiculata sessilia plana v. concava 1-nervia pallide viridia 7–15 mm longa 0.8–1.5 mm lata; cymae terminales folia superantia pauci- v. multicapitatae 1.5–4 cm latae ut caules hirtellae; capitula anguste cylindrica 5-flora fructu 1.2–1.5 cm alta (pappo incluso); involucri valde gradati 4-seriati 9.5–11 mm alti phyllaria in ordinibus 5 perpendiculatis ordinata linearia v. extima lineari-oblonga obtusa v. acutiuscula non valde carinata 0.8–1.2 mm lata dorso glabra vel extima parce hirtella substraminea scarioso-marginata margine prope apicem eroso-ciliata exteriora apice viridia; flores maturi involucro multo longiores; corollae tenues prope basin faucis parce puberulae ut videtur pallide flavae (6.3) 7.3–8.2 mm longae (tubo 1.8–2.3 mm, fauce 4.5–4.7 mm, dentibus 1–1.5 mm longis); achenia linearia 4.2–6 mm longa 6–8-nervia infra glabra supra dense glandulosa glandulis brevissime stipitatis; pappus vix copiosus stramineus corollam maturam aequans 8–9 mm longus, setis subequalibus hispidulis prope apicem longius hispidulis; antherarum appendices anguste lanceolatae 0.5–0.8 mm longae; styli rami 3–4 mm longi, lineis stigmaticis 1.3–3 mm appendicibus anguste subulatis hispidulis (1) 1.3–1.7 mm longis.

ARIZONA: On limestone slope in edge of piñon belt, easterly base of San Francisco Mountain, 45 miles from Flagstaff, Sept. 26, 1920, *H. M. Hall* 11184 (Herb. Univ. Calif. no. 205824); between Williams and Grand Canyon, west of San Francisco Mountain, on plains, Sept. 27, 1920, *Hall* 11199 (type no. 1288511, U. S. Nat. Herb.; duplicate, Herb. Univ. Calif. no. 205819); open rocky park, Tusayan Forest, T. 23 N., R. 3 E., altitude 2,135 m, Sept. 9, 1912, *A. D. Read* 165 (U. S. For. Serv. Herb. 5439).

This little shrub, known from three collections from the general region of San Francisco Peak in northern Arizona (Coconino County), is of considerable interest. Hall's specimens were identified by him as *Chrysothamnus depressus* Nutt., and the measurements of floral details (not made by Hall himself, and in part not agreeing with my own measurements from the same specimens) attached to the sheets in the University of California Herbarium are given in his table of measurements of that species. The sheet in the U. S. Forest Service was originally identified by Dr. E. L. Greene as *C. pulchellus* (Gray) Greene, and later by the writer as *C. vaseyi* (Gray) Greene. It is rather surprising that the specimens should have been identified as *C. depressus* and *C. pulchellus*, since they completely lack the outstanding characteristic of these two species, namely strongly acuminate or cuspidate and strongly keeled phyllaries arranged in five very distinct vertical ranks. Their separation from *C. vaseyi*, with which as well as the two species just named they share the character of a merely glandular achene (not densely pubes-

cent, as in the forms of *C. viscidiflorus* hitherto known), is much less readily made. *Chrysothamnus vaseyi*, which is not known from Arizona, is closely similar in habit to the new plant; its branches, although described by Gray, Rydberg, and Hall and Clements as glabrous, are often puberulous, but much less coarsely so than in the new plant, and never with glandular-capitate hairs developed; its leaves (sometimes finely puberulous) are normally longer and wider, with a weaker costa, usually indicated on the upper leaf surface, where the midrib in the new form is most prominently developed, only by an impressed line; its involucre is shorter (5.5–7 mm high), of broader and blunter phyllaries with less evident keel; its corollas are shorter (5.5–6.5 mm long), with relatively longer teeth (1.5–2 mm long); and its achenes are 9–10-nerved.

In achenial characters var. *molestus* is more like *C. vaseyi*, in which the achene is 9–10-ribbed, glabrous or glandular or rarely sparsely pubescent above, than the forms of *C. viscidiflorus*, in which the achene is about 5-nerved and almost always more or less densely pubescent but not glandular. The only previous record of the occurrence of nearly glabrous achenes among the forms of *C. viscidiflorus* seems to be in *C. marianus* Rydb., synonymized by Hall and Clements with *C. viscidiflorus* subsp. *puberulus*, apparently correctly. In this the achenes were originally described as only slightly strigose, and in the type specimen (*Rydberg & Carleton* 6993) are said by Hall and Clements to be sparsely strigose or nearly glabrous.

The degree of variation in the proportions of the parts of the style in var. *molestus* is considerable and suggests that the emphasis placed on this feature by Hall and Clements in their monograph of *Chrysothamnus* may have been exaggerated. In the three collections now at hand, coming from a restricted region and extremely similar in all other characters, the style branches in normally developed flowers vary from 3 to 4 mm in length, the stigmatic lines from 1.3 to 3 mm, and the appendages from 1 to 1.7 mm, the appendages being sometimes distinctly longer than the stigmatic lines, sometimes slightly less than half as long.

Var. *molestus* is distinguished from all the forms of *C. viscidiflorus* hitherto known by its coarser pubescence consisting in part of gland-tipped hairs, its longer involucre, and its glandular achenes. In many of its characters it is more or less intermediate between *C. depressus* and *C. viscidiflorus* var. *elegans*, and might almost as well be considered a variant of *C. depressus* with blunt phyllaries. The varietal name refers to the difficulties its recognition introduces into the preparation of a key to the species of the genus. Hall states that the specimens collected under his no. 11184 were much browsed back by grazing animals.

Chrysothamnus greenei (Gray) Greene var. **filifolius** (Rydb.) Blake

Chrysothamnus filifolius Rydb. Bull. Torrey Club **28**: 503. 1901.
Chrysothamnus greenei subsp. *filifolius* Hall and Clements, Phylogen. Meth. Taxon. 191. 1923.

Chrysothamnus nauseosus (Pall.) Britton var. **turbinatus** (Jones) Blake

Bigelovia turbinata Jones, Proc. Calif. Acad. II. **5**: 691. 1895.
Chrysothamnus turbinatus Rydb. Fl. Rocky Mts. 859. 1917.
Chrysothamnus nauseosus subsp. *turbinatus* Hall and Clements, Phylogen. Meth. Taxon. 217. 1923.

Achaetogeron chihuahuensis Larsen, sp. nov.[2]

Herba annua (?) 10–30 cm alta pluricaulis; caules simplices v. parum ramosi adscendentes v. decumbentes 1–2-capitati saepe purpurascentes foliosi subdense pilosi v. hirsuti pilis infra patentibus supra adscendentibus v. subappressis; folia infima anguste spathulata v. oblanceolata longe petiolata utrinque pilosa v. hirsuta integra v. utroque latere 1-dentata obtusa v. acutiuscula 2–4 cm longa (petiolo incluso) 3–4 mm lata, caulina anguste oblanceolata v. linearia sessilia v. inferiora petiolata sursum sensim reducta; pedunculus 1.5–6 cm longus nudus v. subnudus adscendenti- v. subappresso-pilosus; capitula solitaria 1.5–2 cm lata; involucri 2-seriati subaequalis 4 mm alti phyllaria lanceolata acuminata patenti-pilosa et minute glandulari-puberula; radii numerosi pauciseriati sicco albidi v. lavandulaceo-tincti; achenia paullum compressa oblonga 2-nervia albida minute hirsutula 0.8 mm longa; pappus minimus coroniformis multisetulosus basi concretus 0.1 mm longus.

ARIZONA: White Mountain Apache Reservation, Apache County, June 25, 1907, *Mrs. Zuck;* semiwaste places, Thompson's Ranch, Black River, White Mountains, July 12, 1910, *L. N. Goodding* 539.

CHIHUAHUA: Vicinity of Madera, alt. 2,250 m, May 27–June 3, 1908, *E. Palmer* 301 (type in Mo. Bot. Gard.; dupl. in U. S. Nat. Herb.), 302438; Colonia Garcia, in Sierra Madre, alt. 2,218 m, June 12, 1899, *Townsend & Barber* 32.

Of interest as the first species of this Mexican genus to be reported from the United States. In general appearance it resembles species of *Erigeron* such as *E. divergens* Torr. and Gray, but it is readily distinguished by the minute coroniform pappus. All the specimens cited are in the U. S. National Herbarium except *Townsend & Barber* 32, which may be present there but has not been located.

Aster commutatus (Torr. and Gray) Gray var. **crassulus** (Rydb.) Blake

Aster crassulus Rydb. Bull. Torrey Club **28**: 504. 1901.
Aster commutatus crassulus Blake in Tidestrom, Contr. U. S. Nat. Herb. **25**: 560. 1925.

Aster commutatus var. **polycephalus** (Rydb.) Blake

Aster scoparius DC. Prodr. **5**: 242. 1836. Not *A. scoparius* Nees, 1818.
Aster polycephalus Rydb. Bull. Torrey Club **33**: 153. 1906.
Aster commutatus polycephalus Blake in Tidestrom, Contr. U. S. Nat. Herb. **25**: 560. 1925.

[2] Description contributed from her unpublished revision of this genus by Esther L. Larsen, now Mrs. Kenneth D. Doak.

Aster arenosus (Heller) Blake

Aster ericaefolius var. *tenuis* Gray, Syn. Fl. 1[2]: 198. 1884.
Leucelene arenosa Heller, Cat. N. Amer. Pl. ed. 1. 8. 1898.

Aster adenolepis Blake, nom. nov.

Machaeranthera mucronata Greene, Pittonia 4: 72. 1899. Not *Aster mucronatus* Sheldon, 1903.

Aster aquifolius (Greene) Blake

Machaeranthera aquifolia Greene ex Woot. and Standl. Contr. U. S. Nat. Herb. 16: 188. 1913.

Erigeron perglaber Blake, sp. nov.

Perennis ut videtur suffrutescens 20 cm altus pluricaulis sparse et obscure stipitato-glandulosus primo visu glaberrimus; caules erecti tenues simplices v. ramo unico erecto donati infra foliosi superne nudi; folia anguste spathulata longe petiolata integerrima obtusa v. acutiuscula coriacea pallide viridia 1-nervia; capitula solitaria longiuscule pedunculata ca. 2 cm lata radiata; involucre ca. 3-seriati paullum gradati 5 mm alti phyllaria anguste linearia acuminata 0.3–0.5 mm lata appressa subchartacea costa glandulari-incrassata minute sed dense stipitato-glandulosa apice sparse ciliata; radii numerosi angusti sicco laete rosei; achenia compressa 2-nervia subappresse hirsuta; pappus duplex, exterior e squamellis lineari-oblongis 0.5 mm longis, interior e setis ca. 12 fragilibus ca. 3 mm longis compositus.

Basal leaves 4–5 cm long including petiole, the blade about 10–14 mm long, 2–2.5 mm wide, gradually decurrent on the petiole, this at base widened and 1-nerved; stems leafy to above the middle, the upper leaves similar to the lower but smaller; petiole bases of old leaves persistent at base of stem; peduncle (naked tip of stem) about 3.5–5.5 cm long, very slender, striate like the stem; disk (as pressed) 6–8 mm high, 10–12 mm thick; rays 40 and more, the tube 2 mm long, puberulous above, the lamina linear, 3-denticulate, 4-nerved, 10 mm long, 1–1.3 mm wide; disk corollas yellow, glabrous on tube and teeth, densely puberulous on lower half of throat, 3.4 mm long (tube 0.6 mm, throat cylindric, 2.3 mm, teeth 0.5 mm long); achenes oblong, 1.5–1.8 mm long; inner pappus of about 12–14 fragile hispidulous bristles, the outer of about as many linear or linear-oblong paleae, sometimes acute and entire, sometimes obtusish and few-dentate, all free; style appendages deltoid, obtusish, hispidulous.

ARIZONA: Without definite locality, 1869, *E. Palmer* (type no. 45116, U. S. Nat. Herb.).

The data for Edward Palmer's "Arizona" specimens of 1869 are so uncertain that this plant is ascribed to the State with some hesitation. However, it appears to represent a species so distinct and unique as to merit description despite some doubt about its habitat. In most of its characters it resembles *E. concinnus* (Hook. and Arn.) Torr. and Gray so strongly that it might almost be considered an essentially glabrous form of that species. The material consists of two specimens, each with a decidedly woody, erect, once- or twice-forked base about 3 cm high, possibly representing the upper part of a much-branched caudex, clothed above with the marcescent bases of the petioles of fallen leaves, and emitting several erect flowering stems. The glands

of stem and leaves are so minute that even under a lens the plant appears glabrous or essentially so except on the involucre and upper part of the peduncles, and even there the glands are very small; the leaves for the most part seem to be completely glabrous.

Erigeron brandegei Gray, still known definitely only from the single scanty specimen collected by T. S. Brandegee on adobe plains, southwest Colorado, in 1875, is intermediate between *E. concinnus* and *E. perglaber*. The extreme base of the specimen (a single stem with abortive terminal head and four 1-headed branches) is not present; the whole plant is finely and sparsely subglandular-puberulous and more densely hirsute with mostly spreading hairs, especially on the lower half of stem, leaves, and apex of peduncles; the involucre is finely subglandular-puberulous, and sparsely spreading-hirsute on the outer phyllaries; and the phyllaries are broader (0.5–0.8 mm) than in *E. perglaber*. The pappus squamellae are long (often 1–2 mm), and irregularly united with each other and with the inner bristles in a manner that certainly indicates an abnormal condition, as Gray suggested.

Galinsoga semicalva var. **percalva** Blake, var. nov.

Achenia radii et disci glabra epapposa.

ARIZONA: Santa Rita Mountains, Pima County, *David Griffiths & J. J. Thornber* 162 (type no. 497226, U. S. Nat. Herb.); Santa Rita Mountains, 1912, *E. O. Wooton* (U. S. Nat. Herb.).

With the narrow leaves and other characters of *Galinsoga semicalva* (Gray) St. John and White, but with achenes of both ray and disk glabrous and completely without pappus. In the typical form the disk achenes are hispidulous and bear a well-developed pappus, those of the ray glabrous or usually hispidulous above on the inner face and provided with a reduced pappus or none.

Actinea quinquesquamata (Rydb.) Blake

Hymenoxys cooperi subsp. *grayi* Cockerell, Bull. Torrey Club **31**: 495. 1904
Hymenoxys quinquesquamata Rydb. N. Amer. Fl. **34**: 114. 1915.

Gaillardia arizonica Gray var. **pringlei** (Rydb.) Blake

Gaillardia pringlei Rydb. N. Amer. Fl. **34**: 139. 1915.
Gaillardia arizonica pringlei Blake in Tidestrom, Contr. U. S. Nat. Herb. **25**: 598. 1925.

Artemisia carruthii Wood var. **wrightii** (Gray) Blake

Artemisia wrightii Gray, Proc. Amer. Acad. **19**: 48. 1883.
Artemisia vulgaris subsp. *wrightii* Hall and Clements, Phylogen. Meth. Taxon. 80. 1923.

Artemisia dracunculoides Pursh var. **dracunculina** (S. Wats). Blake

Artemisia dracunculina S. Wats. Proc. Amer. Acad. **23**: 279. 1888.
Artemisia dracunculus subsp. *dracunculina* Hall and Clements, Phylogen. Meth. Taxon. 116. 1923.

BOTANY.—*Arizona plants: A new variety and new names and combinations.*[1] ROBERT H. PEEBLES, U. S. Bureau of Plant Industry, and LOUIS C. WHEELER, University of Missouri. (Communicated by T. H. KEARNEY.)

In recent numbers of this JOURNAL, several novelties were published by the writers and their collaborators, in the course of preparation of a flora of Arizona. The need has arisen since for publication of a few additional names.

Ephedra cutleri Peebles, nom. nov.

Ephedra coryi var. *viscida* Cutler, Ann. Missouri Bot. Gard. **26**: 413. 1939.

In view of the ease with which *E. cutleri* can be recognized, its great abundance, dominating habit, comparatively wide distribution, and doubtful affinity with *E. coryi* Reed, it seems proper to regard it as a specific entity. According to Cutler (*ibid.*), this *Ephedra* occurs in southwestern Colorado, southeastern Utah, northwestern New Mexico, and northeastern Arizona, thus being geographically distinct from *E. coryi*, which has been reported only from western Texas. Morphologically, it differs from *E. coryi* in having the aerial stems more or less woody, frequently branched, often viscid, and the bracts of the mature fruiting cones not fleshy. *E. cutleri* seems to be most closely related to *E. viridis* Coville, although differing from that species in having shorter, often viscid stems, and long-peduncled ovulate cones. The geographical distribution of *E. cutleri* and *E. viridis* are mainly distinct, although both species occur in Coconino County, Ariz.

Dalea amoena Wats. var. **pubescens** (Parish) Peebles, comb. nov.

Parosela johnsoni var. *pubescens* Parish, Bot. Gaz. **55**: 308. 1913.
Psorodendron pubescens Rydb. N. Amer. Fl. **24**: 44. 1919.

Euphorbia palmeri S. Wats. var. **subpubens** (Engelm.) Wheeler, comb. nov.

Euphorbia subpubens Engelm. in S. Wats. Bot. Calif. **2**: 76. 1880.

Euphorbia incisa Engelm. var. **mollis** (Norton) Wheeler, comb. nov.

Euphorbia schizoloba Engelm. var. *mollis* Norton, N. Amer. Euphorbia sect. Tithymalus. 43. 1899 (preprint from Ann. Rep. Missouri Bot. Gard. **11**: 127. 1900).

Opuntia whipplei Engelm. & Bigel. var. **enodis** Peebles, var. nov.

A forma typica tuberculis baccae latis humilibus distinguitur.

Type: North end of Hualpai Mountain, Mohave County, Ariz., altitude 4,200 feet, *Peebles SF 883*, April 19, 1935.

Although the fruit of *Opuntia whipplei* is described as not being very prominently tuberculate, Engelmann and Bigelow evidently used the term in a comparative sense. The illustration accompanying the original description shows the fruit to be rather strongly tuberuclate, and it was thus interpreted by Britton and Rose in their monograph of the Cactaceae. The usual form of this common Arizona species bears prominent, high, laterally compressed tubercles. In the variety *enodis* the tubercles are broad, low, and not prominent. The variety is known only from the type collection.

Sterile fruits occur in typical *O. whipplei* and in var. *enodis*, but the presence or absence of seeds does not materially affect the appearance of the berry.

[1] Received August 6, 1940.

ZOOLOGY.—*The nematode genus* Raillietnema *Travassos, 1927.*[1]

A. C. WALTON, Knox College. (Communicated by E. W. PRICE.)

The genus *Raillietnema* was established by Travassos in 1927 for those species of cosmocercoid nematodes that show simple basically amphidelphic uteri, a small number of relatively large ova, a vulva opening posterior to the midregion of the body, a much simplified male reproductive structure, subequal spicules, and a very small accessory piece. *Oxysomatium simples* Travassos, 1925—from *Hyla faber*, Brazil—was made the type species. In 1931 Travassos added *Aplectana loveridgei* Sandground, 1928—from *Scolecomorphus vittatus*, Africa—to the genus, and the present paper adds a third species. Semenow (1929) added *Oxyuris praeputialis* Skrjabin, 1916, to the genus, but this form lacks an accessory piece and has complex ovarian coils ending in uteri containing many eggs of relatively small size. As was pointed out earlier (Walton, 1933) this species must be excluded from the genus *Raillietnema* as it is now constituted.

Restudy of material believed to be *Raillietnema simples* (from *Hyla faber*—Brazil) and *R. loveridgei* (from *Scolecomorphus unicolor*—Tanganyika Territory, Africa) supports the grouping of the two species into a single genus, and the finding of a third species with similar characteristics in *Scolecomorphus uluguruensis* (from Lyingwa, Tanganyika Territory, Africa) seems to justify the establishment of *Raillietnema* as a valid genus of the family Cosmocercidae.

Raillietnema simples (Travassos, 1925) Travassos, 1927 Fig. 1

Examination of both male and female material from the type host, *Hyla faber* (from Brazil), adds little to the original description except to point out that the male possesses very narrow caudal alae, which extend from just in front of the cloaca to a point midway along the length of the tail, and that these alae are supported by 4 of the 10 pairs of papillae characteristic of the species. Narrow lateral ridges are present in both sexes, extending from the anterior esophageal to the postanal region. This character is present in all three species of the genus. The excretory vesicle is heavily cuticularized, as it is in the other two species, but is characteristically cylindrical, not spherical, in form.

Male.—Length, 1.6–1.75 mm; greatest width, 0.076–0.082 mm; pharynx length, 0.029–0.032 mm; esophagus length, 0.37–0.405 mm; esophageal bulb measures 0.052–0.057 mm by 0.052–0.057 mm, with a neck 0.047–0.05 mm in length; head-nerve ring distance, 0.195–0.21 mm; head-excretory pore distance, 0.385–0.405 mm; cloaca-tail distance, 0.165–0.171 mm; spicule length, 0.218–0.221 mm; accessory piece length, 0.0159–0.0163 mm; caudal papillae arrangement, 2 pairs precloacal and 8 pairs postcloacal, with 1 pair of precloacals and 3 pairs of postcloacals supporting the caudal alae.

[1] Received June 20, 1940. Contribution from the Biological Laboratories of Knox College, no. 68.

One median unpaired precloacal papillus is present. Narrow lateral ridges extend almost the entire length of the body.

Female.—Length, 2.35–2.72 mm; width at vulva, 0.105–0.141 mm; pharynx length, 0.034–0.038 mm; esophagus length, 0.49–0.51 mm; esophageal bulb measures 0.07–0.072 mm by 0.07–0.072 mm, with a neck 0.05–0.053 mm in length; head-nerve ring distance, 0.245–0.251 mm; head-excretory pore distance, 0.48–0.51 mm; anus-tail distance, 0.22–0.245 mm; vulva-tail distance, 1.19–1.38 mm; larvated eggs measure 0.09–0.12 mm by 0.22–0.24 mm; 2–4 eggs in each uterus. Narrow lateral ridges along almost the entire length of the body.

Host.—*Hyla faber*—Brazil.

Habitat.—Large intestine and the lower end of the small intestine of the host.

Raillietnema loveridgei (Sandground, 1928) Travassos, 1931 Fig. 2

Study of both male and female material collected from three specimens of *Scolecomorphus unicolor* (taken July 1939, at Magrotto Mountain, Tanganyika Territory, Africa) adds but little to the original description. Both sexes have narrow lateral ridges extending almost the entire length of the body, and the excretory vesicle of each is subspherical in shape. One pair of precloacal and one pair of postcloacal papillae support the caudal alae in the male; the third pair of papillae is postalar in position. The number of ova in each uterus is somewhat greater than in *R. simples*, but is still relatively low.

Male.—Length, 1.81–2.01 mm; greatest width, 0.109–0.12 mm; pharynx length, 0.021–0.032 mm; esophagus length, 0.363–0.4 mm; esophageal bulb measures 0.055–0.08 mm by 0.055–0.08 mm, with a neck 0.06–0.07 mm in length; head-nerve ring distance, 0.145–0.15 mm; head-excretory pore distance, 0.326–0.363 mm; cloaca-tail distance, 0.07–0.08 mm; spicule length, 0.175–0.2 mm; accessory piece length, 0.035–0.039 mm; caudal papillae arrangement, one pair precloacal and two pairs postcloacal, with the last pair caudad to the alae. One median unpaired precloacal papillus is present. Narrow lateral ridges extend almost the entire length of the body.

Female.—Length, 2.141–3.025 mm; width at vulva, 0.127–0.15 mm; pharynx length, 0.024–0.03 mm; esophagus length, 0.34–0.42 mm; esophageal bulb measures 0.075–0.09 mm by 0.075–0.09 mm, with a neck 0.07–0.085 mm in length; head-nerve ring distance, 0.152–0.175 mm; head-excretory pore distance, 0.35–0.375 mm; anus-tail distance, 0.09–0.115 mm; vulva-tail distance, 0.6–0.95 mm; larvated eggs measure 0.076–0.1 mm by 0.14–0.16 mm; 6–7 eggs in each of the uteri. Narrow lateral ridges extend almost the entire length of the body.

Hosts.—*Scolecomorphus unicolor, S. vittatus*—Africa (Tanganyika Territory).

Habitat.—Large intestine of the host.

Raillietnema multipapillata, n. sp. Fig. 3

Scolecomorphus uluguruensis (taken at an altitude of 8,000 feet near Lyingwa, Tanganyika Territory, Africa, in October, 1926) is the host for a third species of *Raillietnema*. Both male and female specimens are available for study.

Male.—Length, 1.82–1.83 mm; greatest width, 0.09–0.1 mm; pharynx length, 0.027–0.03 mm; esophagus length, 0.33–0.345 mm; esophageal bulb measures 0.07–0.08 mm by 0.07–0.08 mm, with a neck 0.07–0.075 mm in

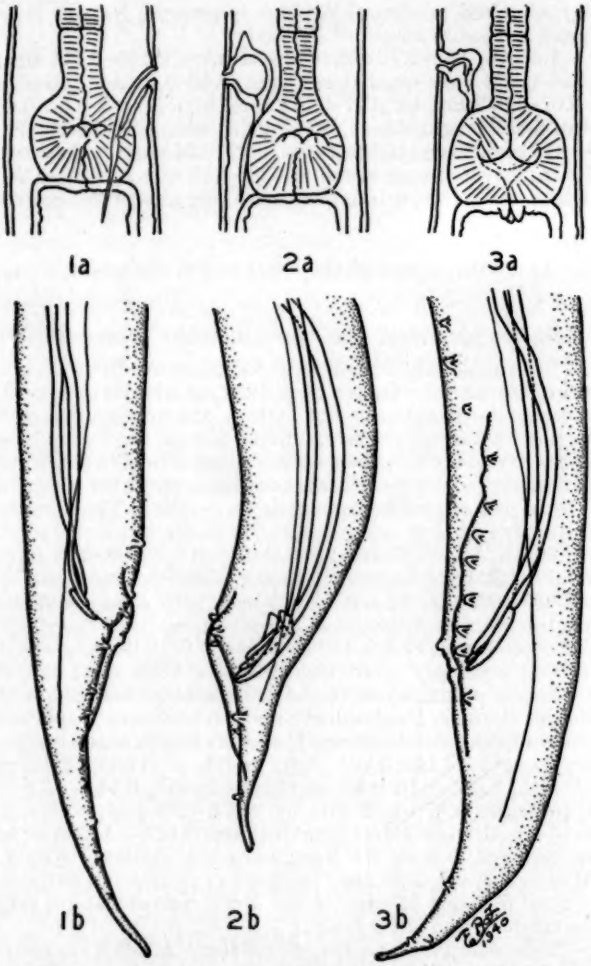


Fig. 1.—*Raillietnema simplex: a*, Esophageo-intestinal junction; *b*, lateral view of tail of male. Fig. 2. *Raillietnema loveridgei: a*, Esophageo-intestinal junction; *b*, lateral view of tail of male. Fig. 3. *Raillietnema multipapillata: a*, Esophageo-intestinal junction; *b*, lateral view of tail of male. (All drawn to the same scale.)

length; head-nerve ring distance, 0.17–0.178 mm; head-excretory pore distance, 0.28–0.3 mm; cloaca-tail distance, 0.12–0.13 mm; spicule length, 0.28–0.291 mm; accessory piece length, 0.036–0.041 mm; caudal papillae arrangement, 10 pairs precloacal and 4 pairs postcloacal, with 7 pairs of precloacals and 1 pair of postcloacals supporting the narrow caudal alae. One median unpaired precloacal papillus present. Narrow lateral ridges extend practically the entire length of the body.

Female.—Length, 2.582–2.702 mm; width at vulva, 0.232–0.261 mm; pharynx length, 0.033–0.037 mm; esophagus length, 0.36–0.4 mm; esophageal bulb measures 0.1–0.125 mm by 0.1–0.125 mm, with a neck 0.1–0.13 mm in length; head-nerve ring distance, 0.175–0.185 mm; head-excretory pore distance, 0.36–0.371 mm; anus-tail distance, 0.161–0.169 mm; vulva-tail distance, 1.075–1.092 mm; nonlarvated eggs measure 0.109–0.113 mm by 0.125–0.13 mm; 6–8 eggs in each of the uteri. Narrow lateral ridges extend almost the entire length of the body.

Host.—Scolecomorphus uluguruensis—Tanganyika Territory, Africa.

Habitat.—Large intestine of host.

Type specimens.—Cotypes are deposited in the collections of the United States National Museum (no. 42090).

Discussion.— Raillietnema multipapillata may be separated from the other two members of the genus on the bases of: (1) A larger total number of caudal papilla, (2) by the greater number of papillae supporting the caudal alae, (3) by the larger number of smaller ova, (4) by the longer spicules, and (5) by the distinctive form of the heavily cuticularized excretory vesicle. *R. loveridgei* has the least number of caudal papillae and the shortest caudal alae, the shortest spicules, and the most complex accessory piece of the three species. The number of ova is intermediate and the excretory vesicle is subspherical in form. In *R. simples* the number of caudal papillae and the size of the caudal alae increase, the spicules are longer, the accessory piece is much reduced, the number of ova is low, and the excretory vesicle is a short cylindrical structure. *R. magnipapillata* has the greatest number of caudal papillae, the longest caudal alae, the longest spicules, a large accessory piece of simple structure, a larger number of smaller ova, and an excretory vesicle shaped like a collapsed sphere with very heavy walls.

The genus *Raillietnema* at present consists of three species, two from African examples of the Apoda and one from a Brazilian tree frog. It seems to act as a connecting link between the cosmopolitan *Oxysomatium-Aplectana* group of quite complex species, on the one hand, and the extremely simplified, secondarily evolved, and geographically localized *Schrankia* species, on the other. The species of this latter genus are reported only from one species of *Leptodactylus* (*L. pentadactylus*) from Brazil. Only one or two eggs seem to mature at any one time in the members of the genus, and the number of spermatozoa is likewise greatly reduced. *Oxysomatium* appears to be nearer the original stem of the cosmocercoids, and from this base has evolved *Raillietnema* and then *Schrankia*. The reduction in the complexity of the reproductive systems is regarded as evidence of secondary, not primary, simplicity of the genera.

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ENTOMOLOGY.—*The North American empoascan leafhoppers of the* alboneura *group* (*Homoptera-Cicadellidae*).[1]

NANCY H. WHEELER,[2] U. S. Bureau of Entomology and Plant Quarantine. (Communicated by J. S. WADE.)

In 1898, Gillette,[3] using external characters only, described the widely distributed American leafhopper *Empoasca alboneura.* At the same time he also described two other species of *Empoasca, mexicana* and *tumida,* having certain external characters similar to those of *alboneura.* In the revision of the genus *Empoasca,* DeLong[4] redescribed the external characters of *alboneura* and included a description and illustrations of the internal male genitalia of this species, pointing out that *tumida* was a synonym and placing *alboneura* next to *aspersa* in the subgenus *Hebata.* Later, DeLong and Davidson[5] described and illustrated *confusa,* which externally closely resembles *alboneura* but internally is quite distinct.

The most distinctive external characters of *alboneura* and closely related species are the more or less bluntly rounded crown and the pale nervures of the forewings, the latter, by contrast, giving to most of the species of this group a more or less striped appearance. The species are all rather robust and range from 2.5 to 3.3 mm in length. In size and shape they are somewhat similar to the species of the *aspersa* group,[6] but are of a duller green color and lack the mosaic pattern of the forewings that is characteristic of the *aspersa* group.

With a view to bringing together the various species of this rather homogeneous group, of which *alboneura* is considered typical, a care-

[1] Received June 19, 1940.

[2] The writer expresses her appreciation to P. W. Oman, of the Division of Insect Identification, Bureau of Entomology and Plant Quarantine, for his cooperation and for furnishing specimens of species recognized by him as undescribed, and to Dr. R. H. Davidson and Dr. D. M. DeLong for the loan of valuable type material.

[3] Proc. U. S. Nat. Mus. 20: 743–744. 1898.

[4] U. S. Dept. Agr. Tech. Bull. 231: 35. 1931.

[5] Ohio Journ. Sci. 36: 229. 1936.

[6] Proc. Ent. Soc. Washington 40: 133–147. 1938.

ful study has been made of the specimens standing under the name *alboneura* in the United States National Museum collection. As a result, the type series has been found to be mixed, containing both *alboneura* and *confusa*. From a further examination of available collections for specimens resembling *alboneura*, two apparently undescribed species have been segregated. The group is now known to contain five different species, three of which have been previously described and illustrated.[7] For convenience, however, illustrations and descriptions of all the species of the *alboneura* group now known to occur in North America are included in this paper, together with some synonymical changes. A key to the males of the group is also offered as an aid in separating the various species.

KEY TO THE SPECIES OF THE ALBONEURA GROUP

1. Lateral processes converging distally.....4. *confusa* DeL. and D.
   Lateral processes diverging distally.....2
2 (1). Dorsal spine vestigial. Lateral process very broad basally, in lateral view tapering abruptly and strongly curved dorsad.....1. *sonorana*, n. sp.
   Dorsal spine prominent. Lateral process relatively slender basally, in lateral view more or less sinuate, with sides almost parallel to near tapered apex.....3
3 (2). Aedeagus with two pairs of spinelike processes projecting dorsocaudad. Apex of dorsal spine short, bluntly pointed..5. *mexicana* Gill.
   Aedeagus without spinelike processes. Apex of dorsal spine attenuated or sharply pointed.....4
4 (3). Dorsal spine sickle-shaped, apex attenuated. Lateral process, in lateral view, with both proximal and distal portions definitely sinuate; distal portion convexly curved on dorsal margin..3. *alboneura* Gill.
   Dorsal spine not sickle-shaped, broad basally, abruptly narrowed medially, and terminating in a slender, pointed, toelike projection. Lateral process, in lateral view, with proximal and distal portions only slightly curved; distal portion concavely curved on dorsal margin.....2. *stylata*, n. sp.

Empoasca sonorana, n. sp. Fig. 1

Resembling *alboneura* in size and general structure, but lacking the strongly contrasting veins of forewing; lateral process very broad basally and dorsal spine vestigial. Length, 3.25 mm.

External characters.—General color pale sordid green; head, thorax, and scutellum sometimes with irregular, paler areas. Posterior margin of seventh sternite of female faintly incised medially and faintly sinuate each side of median incision.

Male internal structures.—Lateral process very broad basally, tapering

[7] Subsequent to the submission of this paper for publication it was found that *Empoasca knulli*, described by Davidson and DeLong (Ohio Journ. Sci. 39: 111. 1939) is a member of the *alboneura* group. The original description, in which the species was compared with *similis* and *bicuspida* (members of the *aspersa* and *fabae* groups, respectively), appeared without accompanying illustrations. *Empoasca knulli* may be differentiated from the other members of the *alboneura* group, here treated, by the bifurcate dorsal spine.

rather abruptly but evenly, in lateral view to sharply pointed apex curved dorsad, in ventral view to bluntly pointed apex directed caudolaterad. Style long, relatively slender, gradually tapering to sharply pointed apex directed caudolaterad. Dorsal spine vestigial. Aedeagus slender, extending upward from base, then bent directly caudad and broadly curved dorsad. Sternal apodemes rudimentary.

Holotype male, allotype female, and 3 male and 20 female paratypes from Cajene, Sonora, Mexico, June 1, 1927, A. W. Morrill, collector.

Type, U.S.N.M. no. 54190.

Empoasca stylata, n. sp. Fig. 2

Related to *alboneura*, but larger, with venation of wings less conspicuous, dorsal spine stouter, and lateral process not broadened distally in ventral view. Length, 3.3 mm.

External characters.—General ground color pale sordid green tinged with fuscous; venation of wings obscure except apically. Crown with ivory spots and an ivory median line. Pronotum marked with three irregular ivory areas anteriorly.

Male internal structures.—Lateral process long, slender, with sides almost parallel to near pointed apex, with distal portion in lateral view concavely curved on dorsal margin and directed dorsocaudad, in ventral view curved caudolaterad. Style long, relatively broad at base, with tip bent laterad. Dorsal spine strongly curved first caudad, then ventrad and cephalad, broad basally, narrowed medially, and terminating in a slender, pointed, toelike projection extending cephalomesad from ventrocephalic margin. Aedeagus stout, process for muscular attachment extending at nearly right angles to shaft. Sternal apodemes fuscous, large, sacklike, and rounded apically.

Holotype male and one male paratype from Cajon Pass, Calif., June 6, 1935, collected by P. W. Oman, and one male paratype from Los Angeles, County, Calif., collected by D. W. Coquillett. The last-mentioned specimen was standing under the name *alboneura* in the Museum collection.

Type, U. S. N. M. no. 54191.

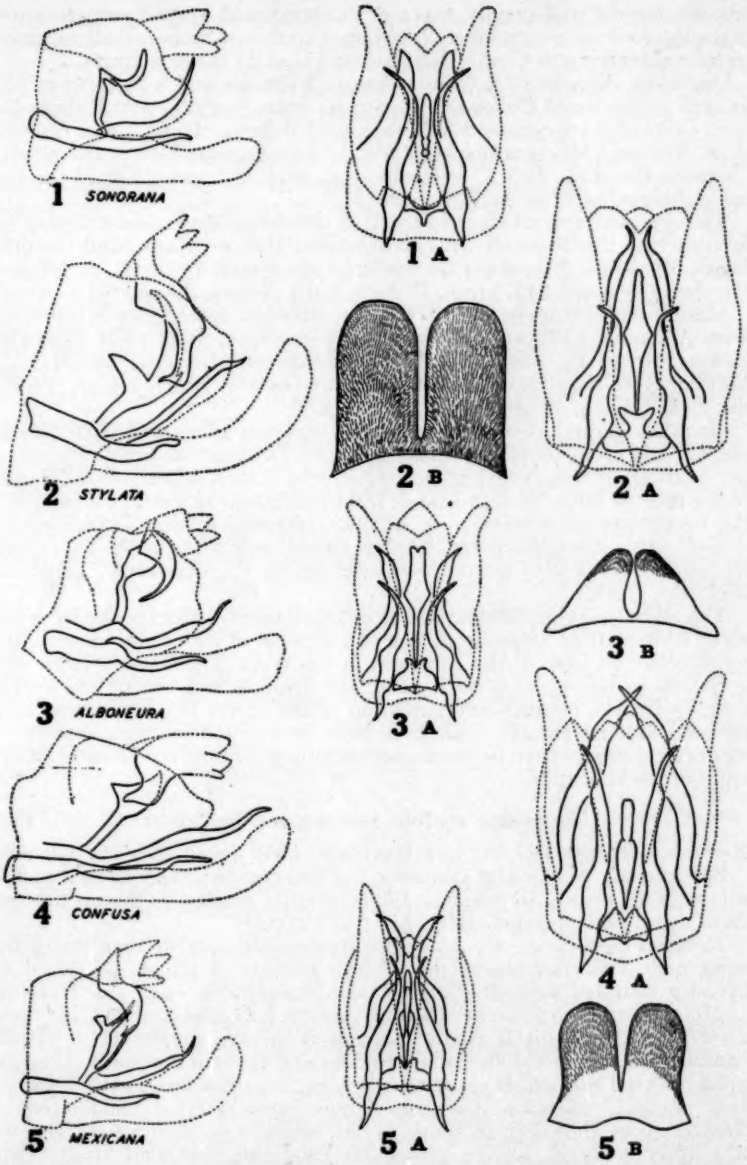
Empoasca alboneura Gillette Fig. 3

Empoasca alboneura Gillette, Proc. U. S. Nat. Mus. **20: 743–744.** 1898.

A relatively robust, dull-green species characterized by the pale nervures of the forewings, giving a conspicuously striped appearance. Lateral processes definitely sinuate and diverging distally; spine stout and sickle-shaped. Length, 2.5 to 3.5 mm.

External characters.—General color varying from yellowish green tinged with orange to dull green tinged with brown, veins pale and conspicuous. Crown relatively broad, bluntly rounded and slightly produced, with a light median stripe and an oblique dash on each side near the eye. Posterior margin of seventh sternite of female produced and rounded medially, with a very shallow and broad lateral emargination.

Male internal structures.—Lateral process in lateral view long, relatively slender and sinuate, with distal portion convexly curved on dorsal margin and tapered to pointed apex directed dorsocaudad; in ventral view, curving mesad to near middle, then laterad, with distal portion slightly broadened, then narrowed to pointed apex directed caudolaterad. Style long, with basal portion relatively broad, sinuate and abruptly narrowed near middle, with apical portion broadly curved and gradually tapered to bluntly pointed apex directed caudolaterad. Dorsal spine relatively stout and sickle-shaped,



Figs. 1–5.—Lateral and ventral (A) views of male genital capsule and ventral view (B) of sternal apodemes of (1) *Empoasca sonorana*, n. sp.; (2) *E. stylata*, n. sp.; (3) *E. alboneura* Gill.; (4) *E. confusa* DeL. and D.; and (5) *E. mexicana* Gill. ×ca. 60.

broadly curved and evenly tapered to attenuated apex directed ventrocephalad. Aedeagus broad distally. Sternal apodemes rather small, narrowed on lateral margins to bluntly rounded and slightly fuscous apices.

Originally described by Gillette from 15 females and 9 males from Mississippi Agricultural College, 2 specimens from Virginia, and 7 specimens from Colorado; specimens were also recorded from "D. C.," and from the U. S. National Museum marked "Va.," "Los Angeles, Calif., Coquillett," "Nevada Co., Cal., Sept.," "Horace, Ks., July 28," and "Neb.," the type being designated "No. 3437 U. S. N. M."

The type series now extant in the U. S. National Museum consists of two females with the Type no. 3437, one labeled Horace, Kans., and the other Lakin (?), Kans. Therefore, Gillette's cotype female in the U. S. National Museum (Type no. 3437) from Horace, Kans., is here designated lectotype.

More recently this species has been identified in miscellaneous collections from Alabama, California, Colorado, Connecticut, District of Columbia, Kansas, Kentucky, Maryland, Mexico, Missouri, Montana, Nevada, New Mexico, New York, North Carolina, Ohio, Oregon, Pennsylvania, Tennessee, Texas, Utah, Virginia, and Wyoming.

In the original description Gillette reported *alboneura* from "native plants" and from plum in Colorado. Later, DeLong[4] recorded this species as "distributed almost throughout the United States on herbaceous plants." Other records have been procured, from collections in various localities, of the occurrence of *alboneura* on alfalfa, *Anthemis cotula*, *Artemisia*, artichokes, aster, *Chrysothamnus*, giant ragweed, and white pine. This species has also been taken in trap lights at Arlington, Va., Knoxville, Tenn., and Richfield, Utah.

The accompanying illustrations and descriptions of this species have been made from a study and comparison of a number of males and females from series collected both in the East and in the West. There seems to be some variation in this species, both externally (in size and coloration) and internally (in the breadth and sinuation of the apical portion of the lateral process), but no greater differences have been noted between eastern and western specimens than between specimens of a series from the same locality and date of collection.

Empoasca confusa DeLong and Davidson Fig. 4

Empoasca confusa DeLong and Davidson, Ohio Journ. Sci. **36**: 229. 1936.

Superficially resembling *alboneura* but less conspicuously striped and less robust, with crown narrower and only slightly produced; lateral processes sinuate but converging distally. Length, 3 mm.

External characters.—General color fuscous-green, with venation of forewing pale. Posterior margin of seventh sternite of female produced and broadly rounded medially, with a small notch, on each side, laterally.

Male internal structures.—Lateral process long and sinuate; in ventral view broad, with distal portion narrowed to long slender point directed caudomesad; in lateral view more slender and tapered gradually to pointed apex directed caudad. Style relatively long, broad at base, with distal portion abruptly narrowed to long, slender apex directed caudolaterad in ventral view. Dorsal spine short, broad, concave on anterior margin, with a bluntly pointed, toelike projection extending cephalad from ventrocephalic margin. Aedeagus simple and relatively slender. Sternal apodemes rudimentary.

Originally described from a single male collected at Burns, Oreg., holo-

type male in the DeLong collection. The male and female herein treated, the former redescribed and reillustrated, are from a series of 18 males and 48 females collected at Mount Shasta, Calif., by R. H. Beamer. Other males and females at hand are from the following localities: CALIFORNIA: Bray (Oman). COLORADO: Durango, Livermore (Oman); Mesa Verde (Beamer); Poudre River Canyon (Sanderson). NEVADA: Reno (Beamer). OREGON: Bend (Oman). WASHINGTON: Cliffdell (Beamer); Mount Rainier (Oman). Four females of this species from Nevada County, Calif., were found under *alboneura* type no. 3437 in the U. S. National Museum collection.

Empoasca mexicana Gillette Fig. 5

Empoasca mexicana Gillette, Proc. U. S. Nat. Mus. **20**: 737–738. 1898.
Empoasca tumida Gillette, Proc. U. S. Nat. Mus. **20**: 744. 1898.
Empoasca bitubera DeLong, Ohio Journ. Sci. **32**: 395. 1932.

One of the smallest species of the *alboneura* group, with crown rounded, but slightly more produced than in *alboneura*. Aedeagus with two pairs of spinelike processes. Length, 2.5 to 2.75 mm.

External characters.—Color yellowish to fuscous-green, with veins of forewing pale but not so distinct as in *alboneura*, except apically. Posterior margin of seventh sternite of female slightly produced and rounded medially, with slight lateral emargination.

Male internal structures.—Lateral process relatively long, broad, and tapered apically; in lateral view extending dorsocaudad, with distal portion narrowed on dorsal margin and curved upward; in ventral view sinuate, curved mesad about middle, with distal portion broadened slightly, then tapered to sharply pointed apex curved laterad. Dorsal spine broad at base, broadly curved caudoventrad, with bluntly pointed apex directed cephalomesad. Aedeagus unusual, having a pair of long, narrow, spinelike processes projecting dorsocaudad from near base and another, shorter pair arising similarly but more dorsally. Sternal apodemes medium sized, slightly fuscous, and rounded apically.

This species was originally described by Gillette from five females collected near Veracruz, Mexico, and was given U. S. N. M. type no. 3430. Later, DeLong redescribed *mexicana*, in the absence of Gillette's type material, from specimens in the collection of the U. S. National Museum, labeled Marfa, Tex., June 5, 1908, Mitchell and Cushman, collectors. As previously indicated by the writer,[8] from an examination of this series now extant, the external markings and internal structures of the male were found to be identical with those described and figured later by DeLong for *bitubera*, and *bitubera*, therefore, was placed as a synonym of *mexicana*.

An examination of the type of *tumida*, a female in the U. S. National Museum, labeled "Colo. 1658" (type no. 3438), has shown this form to be specifically identical with females from Marfa, Tex., identified as *mexicana* by DeLong. Therefore, *Empoasca tumida* is also placed as a synonym of *E. mexicana*.

For the sake of uniformity, *mexicana* is herein redescribed and reillustrated from the series collected at Marfa, Tex., June 5, 1908, now consisting of 1 male (dissected), 3 females, and 2 specimens with abdomens missing. Other material has been examined from various localities in Arizona, California, Colorado, Nevada, New Mexico, Texas, and Utah.

[8] Journ. Washington Acad. Sci. **29**: 300. 1939.

PROCEEDINGS OF THE ACADEMY AND AFFILIATED SOCIETIES

THE ACADEMY

362D MEETING OF THE BOARD OF MANAGERS

The 362d meeting of the Board of Managers was held at the Cosmos Club on Friday, June 28, 1940. President Crittenden called the meeting to order at 8:04 P.M. There were 11 present as follows:

E. C. CRITTENDEN	E. W. PRICE
F. D. ROSSINI	C. L. GARNER
F. C. KRACEK	W. W. DIEHL
H. S. RAPPLEYE	and by invitation
A. H. CLARK	F. G. BRICKWEDDE
P. C. WHITNEY	N. R. SMITH

President CRITTENDEN announced the appointment of the following committees:

COMMITTEES ON AWARDS FOR SCIENTIFIC ACHIEVEMENT FOR THE CALENDAR YEAR 1941

For the Biological Sciences

A. H. CLARK, chairman	I. T. HAIG
F. O. COE	C. F. W. MUESEBECK
J. M. COOPER	H. W. SCHOENING
H. A. EDSON	G. STEINER
E. A. GOLDMAN	A. WETMORE

For the Physical Sciences

O. H. GISH, chairman	F. L. MOHLER
A. K. BALLS	W. T. SCHALLER
F. S. BRACKETT	J. H. TAYLOR
W. E. DEMING	O. R. WULF
H. E. MCCOMB	E. G. ZIES

For the Engineering Sciences

F. M. DEFANDORF, chairman	H. N. EATON
C. H. BIRDSEYE	A. C. FIELDNER
H. L. CURTIS	H. C. HAYES
H. G. DORSEY	G. W. MUSGRAVE
W. N. SPARHAWK	

COMMITTEE ON MEETINGS TO SERVE UNTIL JUNE 1941

C. L. GARNER, chairman	W. C. LOWDERMILK
R. E. GIBSON	P. A. SMITH
L. V. JUDSON	CHARLES THOM

Chairman N. R. SMITH, of the Committee on the Records of the Academy, presented the following recommendations, which were accepted by the Board with instructions to the committee to prepare the appropriate amendments to the bylaws for submission to the members:

1. That there be created the office of Archivist, whose duties would be: *First*, to go over the present accumulation of material, sort out the important records, and

arrange and keep them in permanent order; *second*, accept and care for the records turned over to him by the Corresponding Secretary each year.

2. That the present duties of the Corresponding Secretary as regards the maintenance of the Academy's permanent records be transferred to the Archivist.

3. That the office of Recording Secretary be abolished, his purely secretarial duties transferred to the Corresponding Secretary, and such permanent records as are now kept by him transferred to the Archivist.

4. That the name of the office of Corresponding Secretary be changed to Secretary.

Under the proposed plan, the Archivist would have charge of the following records which are now in the hands of the Corresponding Secretary:

1. A set of the Proceedings of the ACADEMY.
2. A set of the bound Journals.
3. A set of the Directories (incomplete, 1900 to 1910).
4. Permanent Minutes of the Board of Managers.
5. A record of Academy officers and organization.
6. Nominations for membership.
7. Important correspondence.
8. Material of permanent interest, medals, invitations, etc.

Your committee further recommends that the Archivist be appointed by the President for a period of three years and that the person selected for the position be one who is interested in this type of work and who has had appropriate experience in the affairs of the ACADEMY.

On the recommendation of the Committee, of which H. L. CURTIS was chairman and CHARLES THOM and P. C. WHITNEY members, the Board approved for presentation to the ACADEMY a revision of the bylaws entitled "Amendment to modify the procedure for amending the bylaws":

ARTICLE IX. Delete lines 1 to 10 and insert the following:

"Amendments to these bylaws shall be proposed by the Board of Managers and adopted by a letter ballot of the members of the ACADEMY, with a two-thirds majority of those voting being required for adoption. When a proposed amendment is sent to the members, there shall also be submitted a statement of the reasons for the proposed amendment. The ballots shall be counted one month after mailing to the members.

"Any affiliated society or any group of ten or more members may request, in writing, the Board of Managers to propose an amendment. The action of the Board in accepting or rejecting this request shall be by a verbal (yea and nay) vote on a roll call, and the complete roll call shall be entered in the minutes of the meeting."

The Corresponding Secretary presented for the Committee on Membership the nominations of 17 persons; one resident and 16 nonresident.

After fixing the next meeting for September or October, the Board adjourned at 9:50 P.M.

GEOLOGICAL SOCIETY

569TH MEETING

The 569th meeting of the Society was held at the Cosmos Club, January 11, 1939, President J. B. MERTIE, JR., presiding.

Informal communications.—T. S. KESLER described some unusual rock structures in northern Georgia.

Program.—C. WYTHE COOKE: *Neptune's racetracks.*

E. CALLAGHAN: *Recent fault scarps in the western part of the Great Basin.*

C. B. HUNT: *Pediments around the Henry Mountains, Utah.*

570TH MEETING

The 570th meeting of the Society was held at the Cosmos Club, January 25, 1939, President J. B. MERTIE, JR., presiding.

Program.—F. P. SHEPARD: *Nondepositional environments off the California coast.*—Bottom sampling by P. D. Trask and reports of bottom conditions coming from the work of the U. S. Coast and Geodetic Survey gave the impression that there were considerable areas off the California coast where deposition is either very slow or nonexistent. Recent work on the *E. W. Scripps*, involving dredging and coring operations over a wide area off this coast, has shown that these nondepositional surfaces are widespread, that they are associated with various topographic environments, and that all depths up to 3,500 meters are involved. The environments having either rock bottom or sediment that appears to be too coarse to be introduced at the present time include: Banks or submarine mountains rising above any part of the sea floor; steep submarine slopes; portions of the continental shelves; and the walls and floors of submarine canyons. With the possible exception of some banks, none of these nondepositional areas were entirely free from recent sediments, but coring and dredging operations gave the indication that the recent sediments in these places form only a thin discontinuous cover over rock or sediments of an older generation.

While basins and troughs off the southern California coast appear to be areas where deposition is important, several of these features were found to have relatively clean sand deposits underneath thin covers of mud. Since silt and clay are known to be the chief sediments contributed at the present time to the basins and troughs, the existence of this sand leads to the suspicion that even in some of these deep depressions deposition of fine grained sediment may have been inhibited in relatively recent time.

The nondepositional surfaces are found for the most part at depths too great for effective wave agitation. However, investigation of the bottom currents by R. Revelle and the speaker in all the principal environments has shown that large eddy movements are taking place with sufficient current velocity to move fine-grained sediment. These currents show no sign of decreasing velocity with increased depth. Furthermore, the discovery of relatively rapid increase in depth from time to time at the heads of submarine canyons and that these depth changes may occur during calm sea conditions suggests that mud flows or other types of submarine landslides are carrying sediments seaward. It seems probable that bottom currents and mass gravity movements are responsible for the nondepositional surfaces.

ERLING DORF: *The stratigraphic significance of the flora of the type Lance formation.*—The Lance formation at its type locality in Niobrara County, Wyo., has previously yielded a dinosaur fauna of the *Triceratops* stage, a fresh-water invertebrate fauna, and a small flora. The flora has never been described or fully studied. During the past two summers a large collection of fossil plants was obtained in this area by the speaker, under joint auspices of Carnegie Institution of Washington and Princeton University.

At present this flora comprises about 75 species, of which 8 are apparently new and 6 are not specifically determinable. More than 75 percent of the species have previously been reported elsewhere. Over 80 percent of these species occur only in formations whose Upper Cretaceous age is not in doubt: the Laramie of Colorado, the Medicine Bow of Wyoming, and the Hell Creek of Montana and the Dakotas.

Only about 10 percent of the species are known from the widespread and well-known Fort Union flora of Paleocene age. Equally distinct from the

type Lance flora is the flora of the non-dinosaur-bearing beds (Tullock and Ludlow), which overlie the dinosaur-bearing beds (Hell Creek) in Montana and western Dakotas. These have previously been considered the upper part of the Lance formation. The known flora of over 50 species of the Tullock and Ludlow is clearly of Paleocene aspect, with about 85 percent of the species recorded only from the overlying Fort Union.

It is apparent that published statements that point out similarity between the Lance and Fort Union floras are erroneous and are based on inclusion in the Lance flora of species known now to have come from horizons in the Tullock or Ludlow of post-Lance age, or from beds that are actually basal Fort Union. The paleobotanical evidence indicates that the Mesozoic-Cenozoic boundary should be placed between the dinosaur-bearing beds (type Lance or Hell Creek) and the non-dinosaur-bearing beds (Tullock or Ludlow). This is in harmony with the known vertebrate evidence and does not appear to be seriously contradicted by the marine invertebrate fauna (Cannonball) associated with the Ludlow of the western Dakotas.

F. E. MATTHES: *Post-Pliocene origin of the glaciers of the Sierra Nevada.*

571ST MEETING

The 571st meeting of the Society was held in the Cosmos Club, February 8, 1939, President J. B. MERTIE, JR., presiding. The following resolution presented by J. S. WILLIAMS, seconded by J. B. REESIDE, JR., was unanimously approved by the Society:

"Mr. President: Dr. GEORGE HERBERT GIRTY, a member of this Society since January 1897, died of heart failure at his home in this city on Friday, January 27. He had recently passed his 69th birthday.

"Dr. Girty was well known to most of the members of this Society either personally or professionally as a specialist on Mississippian, Pennsylvanian, and Permian fossils. In that capacity he has cooperated, both in the laboratory and in the field, with many members in the solution of geologic problems in many States and in Alaska. The demands of his position made him spend considerable time on stratigraphic paleontology, but his greatest interest was in the field of descriptive paleontology, and he used to sit by the hour often with the bright summer sunshine streaming in through an open window, dictating descriptions of species to his stenographer. Never a showman in his professional work, many observations of great importance are rather apologetically made and obscurely placed within the texts of his descriptions of species. Many of these have been given prominence by later writers. Other observations of equal importance have never been written, because Dr. Girty belonged to the school of geological thought that believes that principles, correlations, and classifications should be based on evidence that is well in hand before they are enunciated. This fact, together with the fact that so much of his time was employed in examining and writing reports on field collections, accounts in part for the relatively small proportion of philosophical papers he published.

"Dr. Girty was author or part author of 9 professional papers and bulletins of the U. S. Geological Survey and of about 50 articles published in various journals and State survey reports. His interests were wide, and at the time of his death he had but recently completed or was working on papers describing fossils from the Mississippian, Pennsylvanian, or Permian rocks from many scattered areas extending from Pennsylvania and Ohio on the east to the Pacific Coast States on the west; and from Texas on the south to Alaska on the north. Perhaps his work best known the world over was his

Guadalupian report, which gave the first extensive description of the Permian faunas of the Southwest. Other papers, however, are known almost as widely. He has contributed through descriptive papers or reports to the knowledge of the Carboniferous geology of almost every State and territory in the United States in which Carboniferous deposits occur and also of Canada, Mexico, and countries on other continents.

"A short biographical sketch written by Dr. Girty a few years ago at the invitation of a British Journal gives many personal details of his life. In it he tells that he was born in Cleveland, Ohio, on December 30, 1869. His parents appear to have been extremely well to do, and from the beginning he lived a rather sheltered life. A great shock, which he says profoundly influenced his life, came when he was 12 years old, when his father died. He was educated in the Cleveland public schools and in Yale University, receiving his Ph.D. degree there in 1894. He came to the Geological Survey in 1895. He was very fond of music and was an accomplshed pianist. In his early youth he considered selecting music as a career, but he gave it up because he felt that his talents were inadequate—"not much above mediocrity," he says. He wrote several compositions for his own pleasure—some of them during his last illness, but he published none of them. He was also fond of poetry and himself wrote poetry. When he started in his college career, he had, as he put it, "an idea" that he would like to teach Latin and Greek, both of which, especially Greek, made a strong appeal to him. His proficiency in these subjects later made him a frequent consultant of Survey members. In his senior year in college he became interested in paleontology, and this interest, as we all know, continued to be his most ardent interest until his death.

"With Dr. Girty's passing, the Society and the science of paleontology have lost an extremely able contributor, and many members of the Society have lost a sincere friend who will be sadly missed. Therefore, I move that these words of appreciation be incorporated in the minutes of this meeting and the Secretary of the Society be instructed to convey to Mrs. Girty the sincere sympathy of the membership of the Society."

Informal communications.—F. E. MATTHES described some artificial geysers near Mono Lake in California, resulting from wells.

Program.—HARRY H. HESS: *Gravity anomalies and structure of the West Indian Island arcs.*

J. C. REED: *Mineralized faults in the Chichagof mining district, Alaska.*

572D MEETING

The 572d meeting of the Society was held at the Cosmos Club, February 22, 1939, Vice-president, JOHN B. REESIDE, Jr., presiding.

Informal communications.—ROBERT P. BRYSON described some crater-shaped depressions in reservoirs, whose origin seems to be associated with gas bubbles that rise through the sediments.

Program.—E. L. STEPHENSON, *The results of magnetometer surveys on laccoliths in the Highwood Mountains, Mont.*—Magnetometer measurements were made on and near the Shonkin Sag and Cowboy Creek laccoliths in the Highwood Mountains in Montana, to trace the buried extension of a horizontal pipelike body and to locate, if possible, the feeders of the laccoliths. Approximately 2,500 readings were made with a standard Askania vertical variometer.

By means of magnetic anomalies the horizontal pipelike body was traced, with reasonable certainty, for a distance of 9,000 feet under a Tertiary gravel bench to a dikelike body exposed at the opposite side of the bench near the

Cowboy Creek laccolith. The measurements show no connection between the laccolith and these two bodies, which, therefore, are not feeders of the Cowboy Creek laccolith.

Areas of great magnetic disturbance occur over parts of each of the two laccoliths. The general form of the anomalies is that commonly associated with relatively narrow bodies of considerable vertical extent. These anomalies may indicate the presence of feeders of the laccoliths, and no other explanation seems more probable at present; however, because other conditions might produce similar anomalies, only tentative conclusions are drawn pending the completion of additional measurements.

JAMES L. DYSON: *Structure and motion of cirque glaciers.*—Detailed study of two cirque glaciers, Sperry and Grinnell, in Glacier National Park has shown that a small cirque glacier in an extreme state of decadence exhibits its structure and other glacial phenomena very clearly. Such glaciers have motion, deposit morainic material, and perform other typical glacier functions. Sperry and Grinnell glaciers are both about the same size, each have a length of approximately one mile.

Stratification due to the annual accumulation of snow is well exhibited on these glaciers. The ice strata, each of which represents one season's snowfall, range in thickness from 2 to 6 feet and are readily apparent because their upper surfaces are covered with dust and small rock particles which make visible contact planes between each stratum. In the narrow firn zone, which lies at the base of the cirque headwall and comprises usually about 8 percent of the surface of the glacier, layers of snow are wedge- or shingle-shaped and have a steep initial tilt toward the glacier front. Weight of the overlying layers causes these wedge-shaped layers of snow to move downward and to rotate so that after traveling a relatively short distance they assume a backward dip, which gradually increases until about midway between the firn-ice boundary and the glacier front a maximum of 45° may be attained. Near the firn-ice boundary, ice strata usually are nearly horizontal or have rotated sufficiently to possess a gentle dip toward the cirque headwall. The thin part of each wedge is removed by melting, and only ice which was originally next to the headwall reaches the glacier front. On both Sperry and Grinnell glaciers the edges of ice strata are distinct enough so that between the firn area and the glacier front their number may be ascertained. Thus the approximate length of time necessary for ice at the glacier front to have moved from the cirque headwall may be determined.

In spite of the small size of these glaciers they are actively eroding the surfaces over which they move. This activity is made manifest by conspicuous amounts of rock flour in their melt waters and by abundant striae on rock surfaces from which the ice has recently retreated. The nature of many of these striae indicates that in places the ice in a very thin zone at the base of the glacier is quite plastic. Because of obstructions in the cirque floor many of the striae are extremely sinuous. Boulders were found that, after being transported in the basal portion of the glacier, were forced into crevices in the cirque floor from which the ice was unable to extricate them. Subsequently the ice was deflected around these boulders as indicated by striae that approach a boulder, curve around it, and then resume a course in direct line with their original trend.

It is suggested also that plasticity of the ice and to a lesser extent its erosive power, depend not so much upon the thickness of the ice as upon the type of internal motion it exhibits.

C. F. BROCKMAN: *Glacial recession in Mount Rainier National Park.*

573D MEETING

The 573d meeting of the Society was held at the Cosmos Club, March 8, 1939, President J. B. MERTIE, Jr., presiding.

Informal communications.—W. W. RUBEY described the work of an advisory committee of naturalists in preserving and making accessible features of interest in the new Government park being developed along the old Chesapeake and Ohio Canal and asked members to help by drawing attention to features that they considered should be pointed out.

R. E. STEVENS presented the results of an analytical study of intergrown albite and mica from a California pegmatite, in which although the two minerals had apparently crystallized simultaneously, the mica contained 10 percent potash and only 1 percent soda, a feature that has a bearing on the existence of the soda mica paragonite.

Program.—MARGARET D. FOSTER: *Geochemical relations of ground waters in the Houston-Galveston area, Tex.*—Ground-water supplies in the Houston-Galveston area are obtained principally from permeable sands in the Willis (?), Lissie, and Beaumont formations. The shallow waters in the different formations differ characteristically in their content of calcium bicarbonate and in their total mineral content. These differences may be correlated directly with the amount and character of soluble material in the sands and clays from which the waters are derived and with the organic content of the soils through which the waters passed in entering the formation.

As they pass downward, the waters in all the formations show a progressive alteration in character, changing from calcium bicarbonate to sodium bicarbonate—a result, apparently, of reaction between the waters and base-exchange minerals in the sands. In waters in the Willis (?) sand, this alteration in type is accomplished by a continuous increase in total mineral content and in sodium bicarbonate; in the waters in the Lissie and Beaumont formations there is a gradual decrease in calcium and magnesium, accompanied by a gradual increase in sodium, the total mineral content remaining fairly constant.

The depth at which the change in character begins to take place differs in the different formations; it is greatest in the Willis (?), least in the Beaumont. Calcium chloride waters found in the vicinity of some of the salt domes may be attributed to the reverse of this softening process; deep salt water, moving upward through faults and fissures and invading the surface strata, reacts with exhausted shallow base-exchange minerals, exchanging its sodium for their calcium and magnesium. Distortion of the strata is indicated by the chemical character of some of the waters in the vicinity of Blue Ridge and Pierce Junction domes.

J. S. VHAY: *Structural features on the north side of the Beartooth Mountains near Nye, Mont.*—From a study of the geology of the Nye #2 quadrangle on the north side of the Beartooth Mountains, Mont., it is concluded (a) that relief to compression during the Laramide orogeny was localized by major zones of weakness in the basement rocks to form two zones of complex structures, and (b) that porphyry bodies along the north zone were intruded previous to the period of major deformation.

The Beartooth Mountains in the southern part of the area studied consist mainly of pre-Cambrian rocks. Along the approximately east-west trending front are steeply dipping Paleozoic, Triassic, and Jurassic formations, similar to those found elsewhere in southern Montana. In the western part of the area the mountains swing to the north and are made up for the most part

of Paleozoic rocks intruded by numerous porphyry masses. The central and eastern part of the area consists of the rather broad valley bottoms of the Stillwater River and its tributaries and intervening terraces and rolling, moderately dissected pediments; it is underlain by Upper Cretaceous formations. To the northeast is an upland of considerably greater relief developed on the pyroclastic Livingston formation.

Regional structural studies have shown that the Beartooth block overthrusts in an easterly direction east of the Nye area, whereas low-angle underthrusting toward the northeast occurs west of this area.

Within the Nye area two zones of complex structures are found. The south zone coincides approximately with the mountain front but passes back into the pre-Cambrian to the west. It trends about N. 80° W. and consists of nearly parallel east-west faults arranged en echelon and dipping steeply south; movement on the faults has been mostly eastward and probably somewhat upward on the south side. The Paleozoic rocks within the fault zone stand at high angles and in places are overturned and cut by subsidiary faults; at the mouth of the Stillwater Canyon they are piled up in a schuppenlike structure north of the main fault.

The northern structural zone is on the line of the Nye-Bowler lineament. In the east half of the area it is characterized by a rather sharp anticlinal structure broken by many small en echelon faults, believed to have resulted from a dominantly horizontal movement along the zone, the south side moving eastward. Farther west along this zone are a number of porphyry intrusives, generally laccolithic in structure. Limestone Butte shows a ring fault offset by radial faults, within which the Paleozoic formations have been pushed up asymmetrically, so that the greatest displacement is on the south side, where Ordovician is against Jurassic, and porphyry masses occur along and on both sides of the fault. Round Mountain is a complex laccolith intruding a syncline, and the elongated dome to the north shows a partly concordant porphyry mass in the nose and northeast flank. Farther west, in Meyers Canyon and its north fork, compound porphyry intrusions have domed up the Lower Paleozoic rocks. The synclines around these domes associated with the porphyry are tightly compressed and in places overthrust by the domes.

Between these two zones in the central and eastern part of the area there is a shallow syncline having sharply upturned edges. Farther west the rocks dip rather uniformly northeast, except near the edge of the quadrangle where they are folded asymmetrically, the axial planes dipping northeast; the folds are cut by a few thrust faults dipping in the same direction.

It is believed that two major zones of weakness, trending about N. 80° W., existed in the basement rock previous to the Laramide deformation. In an early stage of the orogeny porphyritic magmas intruded the sediments along the north zone, and perhaps the eastern part of the Beartooth block was bowed up relative to the western part and to the surrounding plains area. During the period of major compression the Beartooth block was pushed toward the ENE. relative to the plains area to the north, so that transverse movement took place on the east-west en echelon faults of the south zone where the Beartooth block stood high, and low angle underthrusting toward the northeast occurred farther west where it stood relatively lower and was opposite the area intruded by porphyry. On the north zone deepseated movement was mainly horizontal, and the individual porphyry masses compressed and overthrust the surrounding synclines.

T. A. HENDRICKS: *Structural interpretation of recent gravity observations in southeastern Oklahoma.*

574TH MEETING

The 574th meeting was held at the Cosmos Club, March 22, 1939, President JOHN B. MERTIE, Jr., presiding.

Informal communications.—W. H. MONROE described a cave in sandstone that had been formed by animals licking away the rock to obtain the small amount of salt in the rock.

Program.—J. F. BELL: *The mechanical deformation of crystals and its relation to structural geology.*

W. H. BRADLEY: *Fossil fish of the Green River formation.*

S. R. CAPPS: *Some Pleistocene placers in Idaho.*

575TH MEETING

The 575th meeting of the Society was held at the Cosmos Club, April 12, 1939, President J. B. MERTIE, Jr., presiding.

Program.—W. F. FOSHAG: *Problems in the study of meteorites.*

LOUIS S. GARDNER: *Displacement along the Hurricane fault in Utah and Arizona.*—The Hurricane fault extends north and south for at least 160 miles in southwestern Utah and northwestern Arizona. At some places it is a single normal fault, but elsewhere it consists of a zone of several closely packed faults showing three periods of movement in Tertiary and Quaternary times. The faults occur at the base of a high, almost unbroken, west-facing escarpment, which is a fault scarp for 30 miles in Utah, but is a fault-line scarp near Mount Trumbull, Ariz. The stratigraphic displacement increases northward from 1,500 feet at the Colorado River to about 10,000 feet near the Pine Valley Mountains in Utah.

At many places 500 to 3,000 feet of the displacement is due to strata of the dropped block bending downward toward the fault. In a distance of half a mile or more the easterly dip increases progressively from less than 5° to more than 25° at the fault. In the raised block to the east the strata are again essentially horizontal. Farther to the east, such faults as the Sevier and West Kaibab also show this feature.

Dutton and others interpreted the structures as representing monoclines that were later cut by great normal faults. This explanation is unsuited to the Hurricane fault zone because the bending, first, is not like that in ordinary monoclines; second, is strictly confined to one side of the fault; third, is closely associated with the fault and apparently dependent upon it; and fourth, it has resulted from repeated movements, the latest of which affected a land surface that is still in existence. Explanations such as drag along the fault, or simple rotation of the dropped block, are also inconsistent with field evidence.

The bending seems to have resulted from a mobile western block sagging irregularly downward away from a stable eastern block. Evidences for this are: (1) The physiographic contrast between the structural valley of Ash Creek immediately west of the fault and the complexly eroded valley of La Verkin Creek nearby to the east; (2) recent headward erosion of Ash Creek tributaries into Great Basin alluvium; and (3) the anomolous arrangement of ridges and valleys that would exist if the land surface deformed by the last down-flexing were restored to its original condition.

J. B. MERTIE, Jr.: *Stratigraphic measurements in parallel folds.*—Two topics are treated in this paper. The first is concerned with the development of methods for analyzing the form and curvature of parallel folds, utilizing actual field data. The second is a presentation of empirical methods for the measurement of stratigraphic dimensions in parallel folds.

The greatest desideratum of structural geologists is a better understanding of the mechanics of folding. For this objective two principal sets of data are available; first, the strength of the materials composing rocks, and second, their observed deformation. While assumptions must still be made regarding the behavior of deeply buried rocks when subjected to stress, it is nevertheless true that greater progress might be made in the study of folded rocks if all the available data could be treated quantitatively. The methods given in the first part of this paper should be useful in analyzing the geometrical forms of parallel folds.

Folded rocks having bedding surfaces which are approximately parallel are said to lie in parallel folds. Utilizing the geometrical idea of an evolute and its involutes, the author offers a more precise two-dimensional definition of parallel folds, and at the same time points out inconsistencies in earlier concepts. Suggestions are also made regarding a three-dimensional classification of parallel folds, and particular attention is directed to the similarity between Appalachian folding and certain three-dimensional graphs of the Bessel function $J_p(x)$, of the real variables p and x.

It is shown that a family of involutes may be regarded as the traces of a set of stratigraphic surfaces, in a plane normal to the axis of an elongate parallel fold; and that comparable planes and involutes may exist for quaquaversal folds. Methods are presented for deriving the differential equation of the normals to a family of involutes, and for obtaining therefrom the differential equation of the involutes. The derivation of the equation of the corresponding evolute is also given. All these equations are obtained from the relationship $\delta = f(x)$, where x represents the varying distances along a geological traverse normal to the strike of the rocks, and δ represents the dip of the rocks corresponding to various values of x. The relationship $\delta = kx$, which is often assumed by geologists in the measurement of stratigraphic thickness, is utilized to exemplify the principle involved in this analysis; and the type of fold which must exist under this assumption is deduced. Geometric methods are also given for accomplishing the same results that are obtained by mathematical analysis.

The second part of the paper deals with the application of mean trigonometric functions in the determination of stratigraphic thickness and other stratigraphic dimensions. In such applications the most general case is assumed, namely, that both the strike and dip of the rocks change from point to point. Where it is possible to obtain a number of observations lying along a straight line of traverse, it is shown that the best possible results will be obtained by deriving the mean trigonometric functions corresponding to these strikes and dips, and by substituting such mean values in homoclinal formulae. This is essentially the method earlier proposed by E. L. Ickes. Where sets of observations lying upon a straight line cannot be obtained, or where for other reasons it is desirable to consider observations in pairs, different methods should be used. One such method is based upon the assumption that $\delta = kx$. Another method, proposed by the author, is developed under the empirical assumption that the traces of parallel stratigraphic surfaces in a plane, normal to such surfaces, may be considered, over short distances, to have the curvature of concentric circular arcs. Under this assumption it is found that $\delta = \text{arc tan } (kx+g)$ where k and g are constants, depending upon the initial and terminal values of the strike and dip. The corresponding mean trigonometric formations are then found to be the following:

$$\overline{\tan \delta} = \int_0^1 (kx + g)\, dx = \frac{k}{2} + g$$

$$\overline{\sin \delta} = \int_0^1 \sin\, [\text{arc tan}\, (kx + g)\,] = \frac{1}{k}\,(\sec \delta_2 - \sec \delta_1)$$

$$\overline{\cos \delta} = \int_0^1 \cos\, [\text{arc tan}\, (kx + g)\,] = \frac{1}{k} \log \left[\frac{\tan \delta_2 + \sec \delta_2}{\tan \delta_1 + \sec \delta_1}\right].$$

For purposes of rapid computation, the logarithms of $\overline{\sin \delta}$, $\overline{\cos \delta}$, and $\overline{\tan \delta}$ have been computed, with an increment of five degrees for the variable, which may be either the strike or the dip. These logarithms are utilized in substituting such mean trigonometric functions in homoclinal formulae.

576TH MEETING

The 576th meeting of the Society was held at the Cosmos Club, April 26, 1939, President J. B. MERTIE, Jr., presiding.

Informal communications.—J. J. FAHEY described peculiar crystals of dolomite embedded in gypsum, which have an octahedral form that simulates the pattern of the isometric octahedron, but the angle between the face and base is 75.5° instead of 70.5° in the octahedron. The crystals actually are the steep-sided rhombohedron, 4041.

H. D. MISER described two thin dolomite layers in the Whitehorse formation in southwest Oklahoma, which, though less than half an inch thick, can be traced over an area of several hundred square miles and form good horizon markers for correlation.

Program.—DAVID GRIGGS: *Convection currents and mountain-building.*—A review of the known forces available for deformation of the earth's crust shows that only those of thermal contraction and subcrustal convection are sufficient in magnitude. Thermal contraction seems unable to supply the amount of contraction required by geologic analysis of the Tertiary mountain system. Mathematical analysis of convection by Vening Meinesz, Pekeris, and Hales indicates that subcrustal convection is probable, and would supply force of the proper magnitude. This paper presents an analysis of the convective movements which suggests that such currents would be periodic, and discusses the implications of this in mountain-building.

A convection-current cycle is suggested which may be correlated with the mountain-building cycle. To study the action of the currents on the crust, a model has been designed to be dimensionally similar to the conditions in the earth's outer shells, and to reproduce in one minute a process which takes a million years in the earth. Moving pictures of this model in action suggest a similarity between the structures so produced and those that are observed in mountains.

C. K. LEITH: *Present state of some international mineral problems.*

577TH MEETING

The 577th meeting of the Society was held at the Cosmos Club, November 8, 1939, President J. B. MERTIE, Jr., presiding.

The following resolution presented by Miss JULIA GARDNER was unanimously adopted by the Society:

"WENDELL CLAY MANSFIELD was born on June 9, 1874, in Charlotte Center in western New York, a little south of Lake Erie and east of Lake

Chautauqua. His A.B. degree was received from Syracuse University in 1908. For the two years following his graduation he taught science in the secondary schools. On June 20, 1910, he entered the Federal service as preparator to Dr. William Healey Dall, replacing the veteran collector Frank Burns. Mr. Mansfield advanced through the usual stages to the rank of geologist and in the meantime had in 1913 received a M.S. degree from George Washington University and in 1927 his doctorate. He was a member of the Geological and Biological Societies of Washington, the Paleontological Society, the Washington Academy of Sciences, and the Geological Society of America. His wife Katherine Gibson Mansfield died several years ago after a long illness, and there were no children. He accepted without bitterness, but with full realization, the comparative loneliness of his later life. He himself was in wretched health for a number of years, but there was no word of complaint or of morbid reflection. He was spared, however, a long dependence that would have been harder than physical pain, for the end came suddenly on July 24, his first day of absence from his office desk. Two sisters, a brother, and two nephews, whom he regarded with pride and affection, survive him.

"Trained under the aegis of Dr. Dall, his natural regard and respect for books and museum collections was deepened and strengthened, and the Tertiary molluscan collections at the United States National Museum bear the imprint of his care. His faunal and stratigraphic studies were focused on the middle and later Tertiary and Pleistocene of the Atlantic seaboard from Virginia to Florida. To those familiar with the deliberation with which he worked, the sum total of his published writings is surprisingly large, and most of his papers include a distinct stratigraphic contribution. He was the first to extend the Yorktown formation inland to Petersburg, Va. The description of the upper Miocene faunas of Florida—those of the Choctawhatchee formation—and their careful zoning are perhaps his most comprehensive works. In this he established the upper faunal and stratigraphic limit of the Miocene, while his work upon the Tampa had greatly aided in fixing the lower limit of the Miocene. His study of the controversial faunal and field relations of the Chickasawhay, on which he was engaged for some months before his death, was sufficiently far advanced so that it can be published in part.

"Possibly the foremost quality of the man and of his work may be indicated by the outmoded word *integrity*. Too little self-assertive and too little self-confident to be sure of the rightness of his own opinions, he was yet tenacious of a belief that he had well considered and made his own. He was never too busy to be approached and gave generously of all that was his, whether material or immaterial. He asked little of life during the later years, and those of us accustomed to the simple tenor of his ways were surprised at the diversity of interests and organizations represented in the chapel filled by those who gathered to pay the final tribute.

"Mr. President, I move that these words of appreciation be incorporated in the minutes of the Society and a copy of this statement be sent to his sister in New Jersey."

The following resolution, presented by W. C. ALDEN, was unanimously adopted by the Society:

"ARTHUR JAMES COLLIER, a member of the Geological Society of Washington, died at Coronado, Calif., on October 13, 1939. Mr. Collier was a member of the United States Geological Survey from 1896 until the time of his retirement in 1935. He was born in Wheaton, Ill., on January 5, 1866.

After moving to the West he attended the University of Oregon, and from this school he received the degrees A.B. and A.M. In 1894, Harvard University conferred on him the degree of Bachelor of Science in consequence of studies there. During the years 1910 to 1914 he served as professor of geology at the University of Oregon.

"Field studies for the Federal Geological Survey resulted in the publication of several papers, by 1908, on gold, tin, and coal deposits of Alaska. Following these came field mapping and published papers on coal and ore deposits in Oregon, Washington, and Idaho. Several years were devoted to mapping and study of the areal geology and structure of the rock formations in several districts in Montana, including coalfields, the Kevin-Sunburst oilfield, the Little Rocky Mountains, Bowdoin dome, and other possible reservoirs of oil and gas. Several papers were issued by the Geological Survey based in these studies, including also oilfields in Wyoming and the Nesson anticline in North Dakota.

"Mr. President, I move that a copy of this statement be incorporated in the minutes and that appropriate words of sympathy be sent to Mrs. Collier."

Program.—K. J. MURATA: *Volcanic ash as a source of silica for the silicification of wood.*—The chemical and physical properties of volcanic ash make it a rich source of readily available silica for geochemical processes. In recent years more and more sedimentary formations are being recognized as containing volcanic ash or its decomposition products. The common association of silicified wood with volcanic ash is noted in a list of occurrences of silicified wood in the United States, and this association is viewed as the result of a genetic relationship arising from the alterability of the ash. Silicified wood may serve as an indicator for volcanic material in sedimentary deposits.

W. D. COLLINS: *Water analyses.*—At one time the main use of water analyses was as a help in judging whether waters were safe to drink. There are still a good many who have no other thought about water analysis. The water analyses made by the Geological Survey have very little value in connection with questions relating to health. The analyses generally show the quantities of a larger or smaller number of dissolved mineral constituents, depending on the use that is to be made of the results. Analyses may be faulty, valueless, or misleading because the samples were not collected properly, because they changed in composition between the time of collection and the time of analysis, or because of errors in the analysis.

It is not easy to obtain samples that are truly representative of the sources from which they are taken. Samples collected in the course of drilling a well may represent water added in drilling rather than water present in the formations reached by the drill. Most surface waters vary so much in composition with the seasons that care must be taken in using analyses of single samples of surface waters. It is possible to take a sample from a river that will represent the water in a particular part of the stream and fail to represent the main body of water in the stream.

There have been occasions when a sample of water has changed appreciably in composition during storage because of solution of the bottle, because of the solution of insoluble matter that was in suspension in the water when collected, or because of the deposition of material that was originally in solution. This deposited material is generally calcium carbonate or hydrated iron oxide.

The special methods and precautions necessary to obtain reliable analyses

of the mineral content of natural waters are not fully appreciated by some analysts who are expert in other lines of analytical work. Not all are familiar with the various checks that can be applied to test the reliability of an analysis. The inaccuracy of many analyses can be detected by inspection, but others equally in error may appear, by every test, to be entirely reasonable and reliable.

To obtain a useful and dependable water analysis it is necessary that the sample be so collected as to be truly representative; that it be submitted for analysis unchanged, and that it be analyzed with due attention to details, with careful scrutiny and checking of the results.

TOM F. W. BARTH: *Thermal activity in Iceland.*—A broad belt of geologically Recent formations traverses Iceland from southwest to northeast. It is the so-called Palagonite formation, which consists of tuffs and breccias associated with basic intrusions, moraines, boulder-clays, and glacial sediments. To this belt is confined the modern volcanicity (volcanoes and fissures such as Trölladyngja, Hekla, Katla, Laki, Vatnajökull, Askja, Krafla, etc.), as well as the *acid hot springs*, which in Iceland invariably are intimately associated with active volcanism. Indeed, acid springs seem to depend on it for their existence; they are given birth by active volcanism, they are changed by volcanic events, and they die when in any local region the volcanism abates. But this does not mean that the acid thermal activity is a modern phenomenon in Iceland. It has been inferred from certain metamorphic clay deposits that the pre-glacial volcanicity also was accompanied by hot-spring action.

The *alkaline hot springs* are geographically independent of the modern volcanism. They are found in the palagonite belt, as well as on either side of this belt, in the formation of Tertiary basalts of both East Iceland and West Iceland.

Other characteristic differences between acid springs and alkaline springs are: (1) Their relation to the surface topography: acid springs are found along tectonic lines and usually on high, dry ridges, but alkaline springs are typical for areas possessing a superior ground-water supply, and break out at the foot of long hill slopes, or in depressions in the land surface, often in river beds or in the bottom of lakes; (2) the alkaline springs are much more copious than the acid ones; (3) the temperature curve is typically different for the two kinds of springs.

Both types of springs are fed by volcanic contributions; they receive their thermal energy as well as certain chemical constituents from volcanic sources. It can be shown that the farther the volcanic emanations have to travel underground before they find egress to the surface and break out as hot springs, the more alkaline they become and the more do they become diluted by ordinary ground water (thus becoming increasingly copious).

This evolution from what in a sense may be called "primary" acid springs of insignificant water discharge to "secondary" alkaline springs of considerable discharge, is in line with, and corroborates the studies conducted by A. L. Day and E. T. Allen on the thermal activity in California and in Yellowstone National Park.

578TH MEETING

The 578th meeting of the Society was held at the Cosmos Club, November 22, 1939, President JOHN B. MERTIE, Jr., presiding.

The following resolution presented by G. F. LOUGHLIN was unanimously adopted by the Society:

"We were very sorry, though not surprised, to learn that Dr. WALDEMAR LINDGREN died on November 4, 1939, at the age of 79, after a long illness. Though not a charter member of the Geological Survey, he was identified with it and with American geology from its pioneer days. Born in Sweden and educated there and at Freiberg, Germany, he came to America in 1883, with a letter of introduction to Raphael Pumpelly, who was conducting the Northern Transcontinental Survey established by the Northern Pacific Railway. Pumpelly assigned him to assist W. M. Davis, who for years afterward used to refer to his young assistant who mounted a horse on the wrong side. This work ended in 1884 and Lindgren worked for a short time as an assayer at Helena and draftsman at Anaconda, Mont., before being appointed assistant geologist in Becker's party, which was studying quicksilver deposits in California for the U. S. Geological Survey. From then until 1912 he remained with the Survey. His ability as a mining geologist, reflected in his Survey reports and scientific papers, soon gained deserved recognition and he became generally regarded as the world's outstanding authority on the science of ore deposits.

"His broad view of the subject is reflected not only in his writings on mining districts and on processes of mineral deposition, but in the time and energy that he spent in placing on a sound basis the Survey's annual statistical reports, which from 1903 on have furnished the basis for a quantitative approach to mining geology. In 1905 he organized the small group that established the journal *Economic Geology*, which promptly became the leader in its field. Lindgren continued for several years in charge of the Metals Section of the Division of Mineral Resources, and in 1908 succeeded S. F. Emmons as chief of the Section of Metalliferous Deposits. He held both positions until 1911, when he was made Chief Geologist, succeeding C. W. Hayes.

"In 1912, with the desire to give more time to original investigations than his administrative duties on the Survey permitted, he resigned to become William Barton Rogers professor of economic geology at the Massachusetts Institute of Technology, where he had been a visiting lecturer for the three preceding years. Years later, when he received the Penrose medal in recognition of his leadership, he said that he never felt cheaper than when he handed his resignation to George O. Smith, who was then director. He had grown with the Survey, and it had been such a great part of his life for so many years that it was hard to reconcile himself to the separation. In 1913 the first edition of his book *Mineral Deposits*, an outgrowth of his lectures, was published. This book also promptly became the leader in its field. He remained at Tech until his retirement about nine years ago and continued to be an inspiration to many graduate students, and an outstanding consulting geologist.

"In 1925 he served as chairman of the Division of Geology and Geography of National Research Council and successfully laid the groundwork for the publication of the *Annotated bibliography of economic geology*, the first volume of which appeared in 1928. He supervised the first 10 volumes, his many contributions to which made interesting and spicy reading, besides showing in few words the relative value of many articles on the subject.

"The science of mineral deposits is by no means a one-man science, but, when we reflect on its growth, we find that no one so much as Lindgren has contributed to and guided its advance.

"Geology and the world has suffered an irreparable loss in his passing, but we are most grateful that he was able to round out his work so well

during his long career. We regret that his period of comfortable relaxation after retirement could not have been longer and we extend our sincere sympathy to his surviving relatives and to the Massachusetts Institute of Technology where he spent the last 27 years of his life.

"Mr. President, I move that the Geological Society of Washington prepare an appropriate resolution of sympathy and send it to Dr. Lindgren's nearest relatives, particularly his niece, Helen Lindgren, who has been his close companion for many years, and to the Massachusetts Institute of Technology."

Informal communications.—J. C. REED and R. R. COATES reported on the thermal gradient in mines on Chichagof Island, Alaska, which they found to be about 1.55° F. per hundred feet. The communication was presented by Mr. COATES.

Program.—P. B. KING: *Persistent structural trends in Guadalupe Mountain region, Tex.*

FRANK NEUMANN: *Seismograph evidence of deep focus earthquakes.*

W. D. URRY: *Measurement of geologic time.*

579TH MEETING

The 579th meeting of the Society was held at the Cosmos Club, December 13, 1939, President J. B. MERTIE, Jr., presiding.

Program.—Vice-president J. T. PARDEE took the chair while President MERTIE delivered his presidential address, *Placer gold in Alaska*, which was published in this JOURNAL, Vol. 30: 93–124, Mar. 15, 1940.

47TH ANNUAL MEETING

The 47th annual meeting of the Society was held immediately following the 579th regular meeting. The reports of the secretaries, auditing committee, and treasurer were read and approved.

The Society elected the following officers for the year 1940:

President: J. T. PARDEE.

Vice-presidents: C. WYTHE COOKE and L. H. ADAMS.

Treasurer: ALICE S. ALLEN.

Secretary: R. W. BROWN.

Council: D. A. ANDREWS, EUGENE CALLAGHAN, C. B. HUNT, C. B. READ, R. E. STEVENS.

The society appointed J. B. MERTIE, Jr., as its nominee for vice-president of the Washington Academy of Sciences.

PARKER D. TRASK, *Secretary*

Obituary

DAVID MYERS MOTTIER, professor emeritus of botany at Indiana University, died at the home of his daughter in Indianapolis on March 25, 1940, after a brief illness, at the age of 75 years. Born September 4, 1864, his early years were spent near his birthplace in a Swiss settlement at Patriot, in southeastern Indiana. Following his attendance at the public schools near his home, he taught for several years in the elementary schools before entering Indiana University as a student. He received the A.B. degree from Indiana in 1891 and the A.M. in 1892.

In his student days at Indiana and the few years immediately following, while he served as instructor in botany, Mottier caught the enthusiasm of such of his instructors and colleagues as David Starr Jordan, John Merle Coulter, and Douglas H. Campbell and, as the next natural step for that time, turned to Germany for further study. His formal graduate work with Strasburger at Bonn resulted in his receiving the Ph.D. degree in 1897. He later spent some time in research at the Biological Station at Naples and at the University of Leipzig.

From the time of his first appointment at Indiana University in 1891 until his retirement in 1937 he served continuously—as instructor, associate professor, professor, and departmental head—except for two leaves for study in Europe.

The pattern of Dr. Mottier's life work took form in that bright decade between 1890 and 1900 when so much was done to clarify the cytological details of the life histories of the higher plants and animals and lay the foundation for the experimental work of the present century. At that time he was acquainted, personally or by correspondence and exchange, with many of the most active workers in his field in both Europe and America. More than two years before the announcement by others of double fertilization in angiosperms, he had made excellent microscopic preparations showing a sperm in contact with the polar nuclei, but he heeded the vigorously administered advice of Strasburger and ignored it as of no consequence. As a symbol of his excellent cytological technique, one of his slides showing this phenomenon was in good condition 30 years later, although it had many times been subjected to projection with an arc light.

His most important early work was on various problems of the cytology and embryogeny of vascular plants. Later he made significant contributions to what was known of the origin and development of chloroplasts and mitochondria. His last work dealt chiefly with the prolonged culture of the gametophytes of ferns under conditions preventing fertilization.

A keen mind, a thoroughness of application, and a master of detailed perfection made him an artist in the techniques of cytological preparation and illustration. These qualities, with his seriousness of purpose in all aspects of teaching, research, and study, and his gentlemanly old-school personal qualities, are reflected in the respect of numerous students who felt his influence.

Besides numerous research papers, he prepared in 1902, under the title *Fecundation in plants*, a résumé of what was then known of fertilization in all groups. He was also the author of an elementary text in botany and a laboratory manual.

Dr. Mottier was a fellow of the American Association for the Advancement of Science, a life member of the Botanical Society of America, a charter member, fellow, and expresident of the Indiana Academy of Science, and a member of the American Society of Naturalists, the Washington Academy of Sciences, and, at times, of several other learned and honorary societies.